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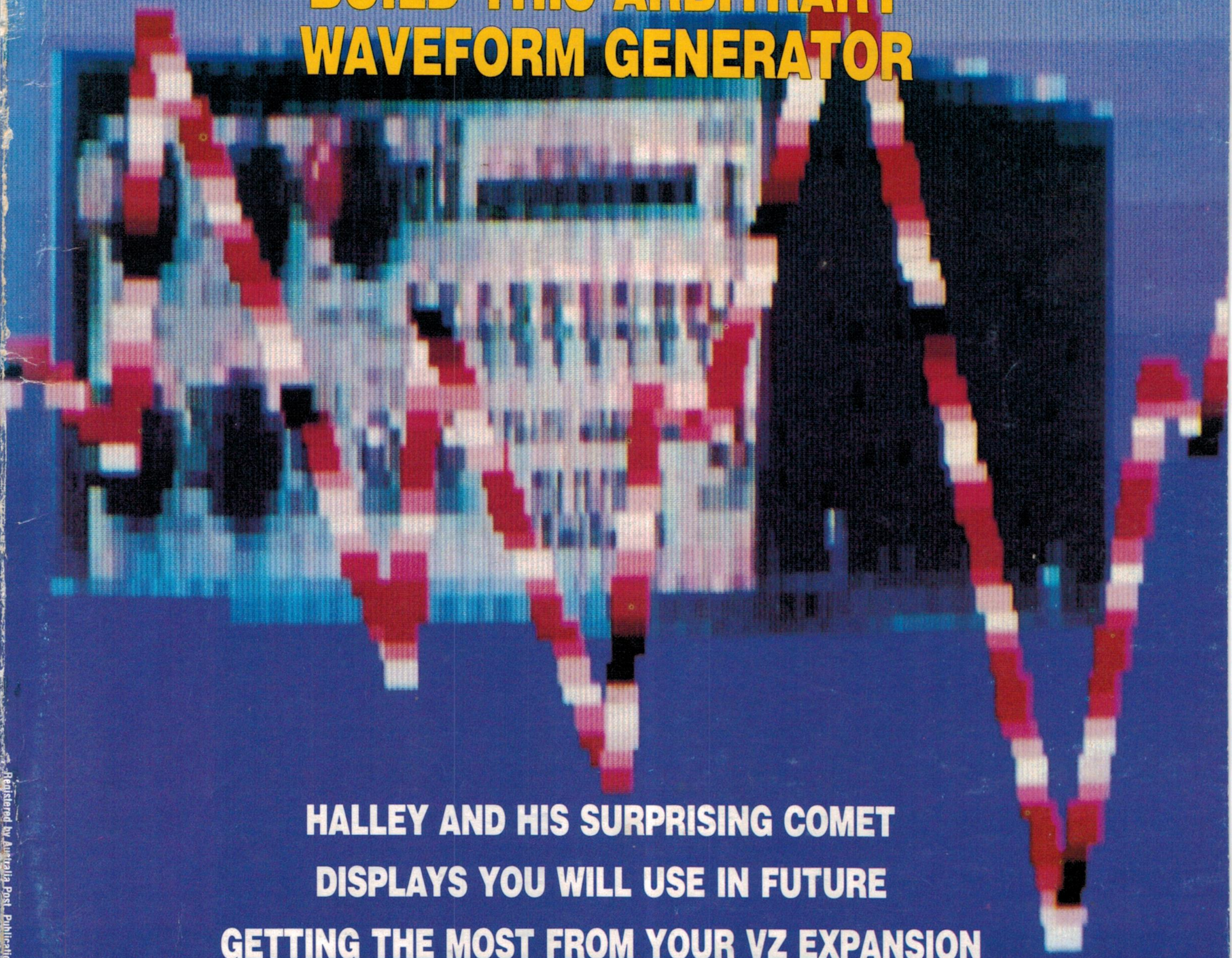

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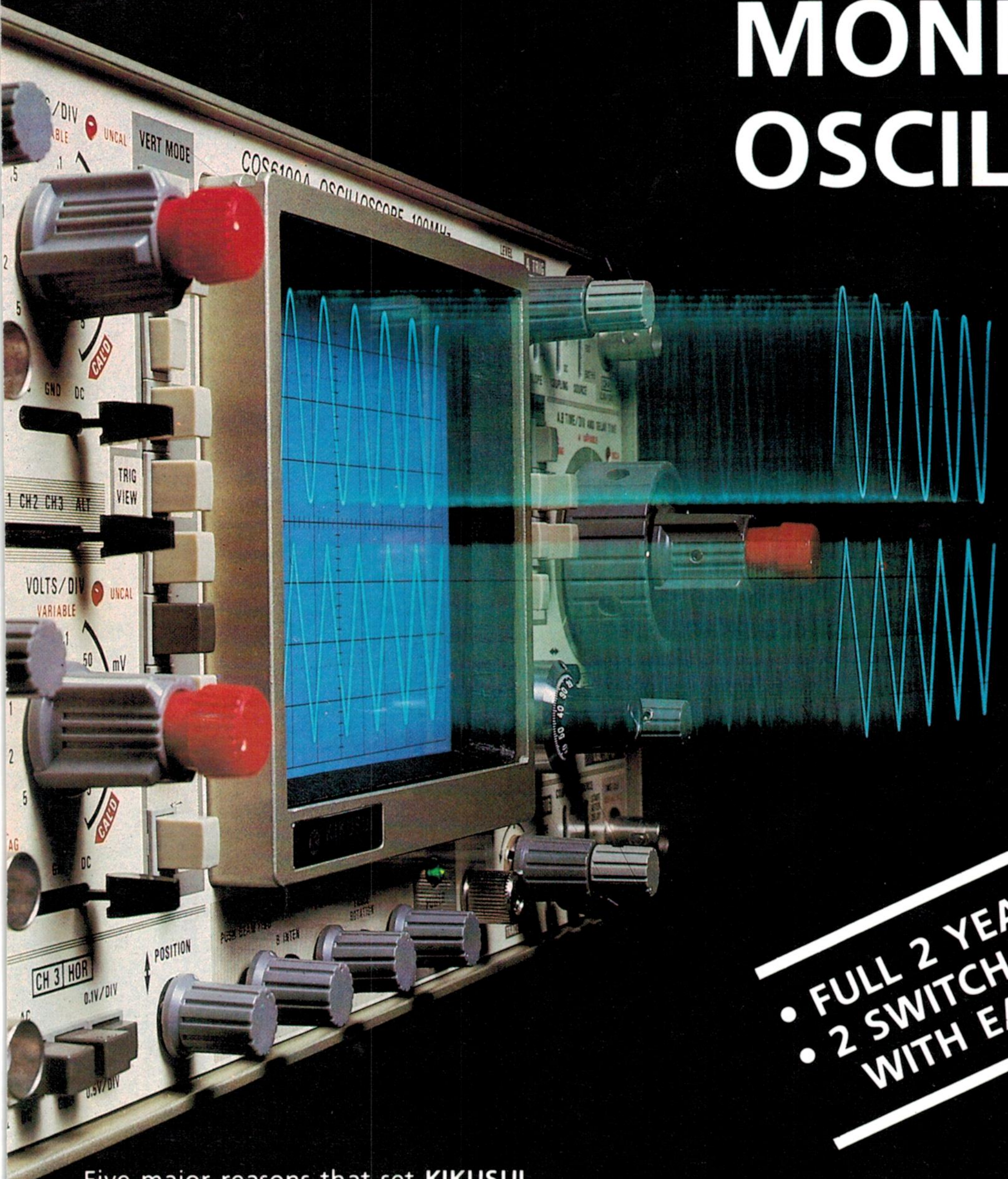

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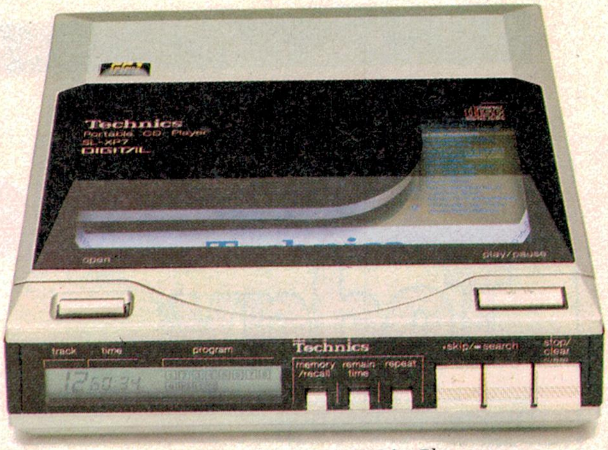
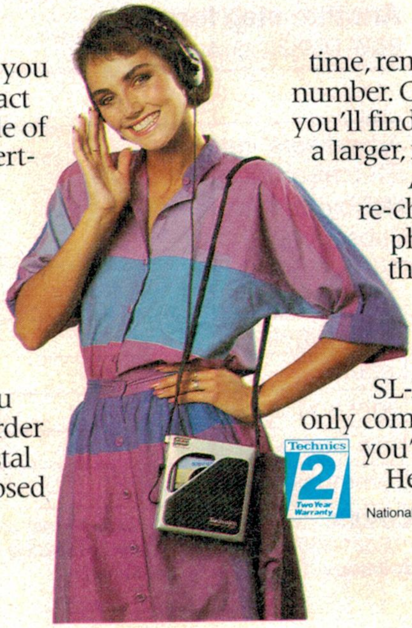


SL-XP7 Portable Compact Disc Player.
Actual size 12.5cm.

If it were any smaller...

you couldn't fit the discs in!



THE NEW Technics SL-XP7 is so small you might mistake it for a stack of compact discs. But it's really a portable capable of playing compact discs with thrilling concert-hall fidelity.

The SL-XP7 uses a combination of friction-free suspension and digital control circuits to protect the sensitive laser pick-up system. This virtually eliminates 'skips' or mis-tracking when the player is being carried around.

Random access programming lets you choose which tracks you want and the order in which you listen to them. A liquid crystal display shows which track is playing, elapsed time, remaining time and programmed track number. Connect the SL-XP7 to your hi-fi and you'll find it lacks none of the performance of a larger, non-portable player.

Add the optional portable pack with re-chargeable battery, and a pair of headphones (Technics suggest that you use their EAH-X15 for the best results) and you've a truly portable CD player.

Indoors or outdoors the SL-XP7 is now the only compact disc player you'll ever need.

Hear it today!

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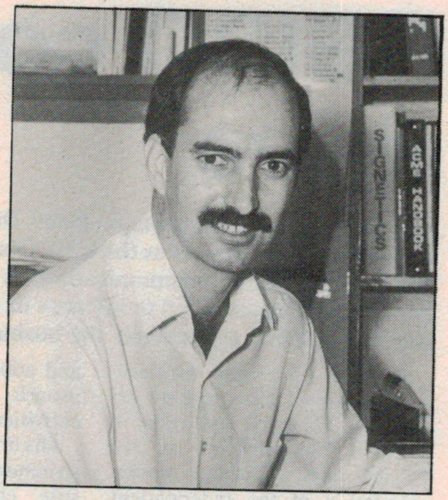


THE AM RADIO STATIONS recently held a press conference to let us know the status of AM stereo. While a large number of the AM radio stations have installed stereo encoding equipment, consumers haven't exactly been falling over each other to buy receivers to decode the stereo signal.

The stations are not really surprised by this, after all the VCR market took about six years to get going. Of course, they would like to speed things up a bit because they are counting on stereo to give their business a boost.

For the most part of last year there wasn't much in AM stereo receivers or tuners on the market to excite people, a situation for which the AM broadcasters are in part to blame.

The market for car receivers fared best. By the end of the year there was a number of products on the market, a couple with excellent specifications. Portable and home AM stereo products have, however, been few in number and poor in quality.

This magazine has had a policy of encouraging the manufacturers to introduce products with high quality AM stereo decoding, but it is an uphill battle.

The world's most popular broadcast receiver is the cheap AM radio. Around the world, broadcasters know their clean wideband signal is being listened to on a radio with less bandwidth than the average telephone.

To compensate they all use equipment (made by Orban or CRL) to boost their signal at around 200 and 2000 hertz. So here's the rub. If, as the stations would have it, you buy a wideband AM receiver, it will sound terrible on highly processed AM stations.

Thus, although the AM stations are quick to blame the receiver makers for the poor quality of receivers, the stations are themselves in part to blame.

They have caught themselves in their own net. If they cease to process they will lose audience, if they don't they will lose it in the long run to the wideband FM stations.

One way out would be for the stations to vary the level of processing as the audience (and their attached receivers) and programme content changes. All stations have two sets of transmission equipment most have two processors. Each processor could be set for a different level of equalisation.

David Kelly
Editor

NEXT MONTH

MIDI THRU BOX

The MIDI standard has been remarkably adhered to in the music industry. It allows information to be sent and received between different manufacturers' synthesisers. This fairly straightforward project is for a device that distributes the data without delay to four outputs.

STARTING ELECTRONICS

Whether you're a handyman, an electronics troubleshooter or a frustrated project builder this article could be your (second) best friend. It's a methodical and logical outline of the things to look for when *the stupid thing just won't go!* So keep the swift kick in reserve and try tracing the possibilities.

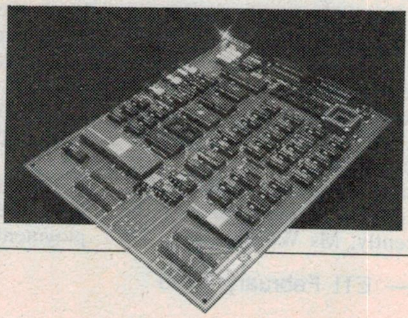
REVIEWS

Next month the two hi-fi products up for review are a pair of Wharfedale Model 708 speakers and the Sony EV-S700ES Video 8. In fact both these reviews are audio reviews. With the Wharfedale speakers this is obvious. The 708s are a response by Wharfedale to meet rising costs and competition with a new speaker cabinet design — amongst other features.

Interest with the Sony Video 8 review lies in the test of the 8 mm video as a sound recording medium. The word is: near CD clarity recording.

MICROPROCESSOR DEVELOPMENT SYSTEMS

We look at the hardware used in the development of software. As with most things the price and quality range from what the hobbyist can afford to top line systems which only businesses could contemplate. We describe what is available and how this equipment can help you in your software development efforts.



CSIRO communications drive

Leading Sydney businessman Peter Dunstan, who recently took up his appointment as the CSIRO's new director of information and public communication, is spearheading a new drive by the organisation to improve its liaison with those outside the CSIRO, particularly the business community.

Dunstan, 51, was formerly general manager, corporate affairs, of Unilever Australia in Sydney. The creation of his CSIRO post was a key recommendation of the independent Myer Committee which urged the organisation to devote a greater share of its resources to communication and to establish a strong corporate image.

"The Myer Committee found that most industry and community leaders had little knowledge of the CSIRO's role," Dunstan said. "I believe that the wide network of business contacts I have built up over 27 year's with Unilver will be of benefit in reaching this group.

Dunstan also believes his knowledge of the industry's needs will enable the CSIRO to speak more directly to industry, and adopt a more vigorous approach in its communication activities.

His brief is to develop policies, structures and procedures to ensure effective communication between the CSIRO and industry, business, government, academic and community leaders and the general public; to coordinate and manage the entire range of the CSIRO's central information services; and to give particular assistance to developing contacts with business. His new role will also involve integrating the CSIRO's Science Communication Unit and the Central Information, Library and Editorial Section (CILES).

CV

Dunstan comes well prepared for the job. Joining Unilever in 1958 he rose from various brand management positions in Australia and the UK to marketing director of Lever Brothers in Malaysia and Singapore by 1969. In 1973, he was appointed to a newly-established strategic planning unit, reporting to the Unilever Australia chairman, which drew up the company's plans for the 1980s, and in 1975 he was appointed general manager of a new department of information and public affairs. In 1978 he was given additional responsibilities for the co-ordination of Unilever Australia's marketing activities and was appointed a permanent member of a new business development unit.

He has held numerous senior positions with major business organisations, including positions of president of the Australian Council of the International Chamber of Commerce, president of the Sydney Chamber of Commerce, president of the Australian Association of National Advertisers and chairman of the Australian Advertising Industry Council. He has been a member of the Executive of the Committee for Economic Development of Australia for nine years.

He is a business representative of the NSW State Cancer Council and a member of the Interim Inspection Policy Council and the National Consumer Affairs Advisory Council. He is also a trustee of the Royal Botanic Gardens and Domain Trust.

Other organisations he has served include the Salvation Army Red Shield Appeal, the Sydney University Appointments Board, the Australian Institute of Political Science, the United World Colleges Trust, the NSW Institute of Technology, the Australian Museum and the Australian Trade Union Program at the Harvard Foundation. He is a fellow of the Australian Institute of Management and the Australian Marketing Institute.

Equal bytes for women

The Women's Bureau of the Department of Employment and Industrial Relations has launched a new video production called "Equal Bytes", aimed at promoting career opportunities and job equality for women in the computer industry.

The video aims to break down occupational segregation by showing women that the acquisition of computing skills can lead to interesting and challenging careers. It shows women a variety of jobs available in the computer industry and the type of training they should seek to pursue careers in this rapidly expanding field.

In introducing "Equal Bytes" at a special screening in Perth recently, Ms Wendy Fatin, MP (representing Employment and Industrial Relations Minister Ralph Willis), said that the video was an important contribution to the growing body of materials designed to encourage women to consider a broader range of options when planning careers. She also pointed out that opportunities existed outside the major cities. In particular, women with skills in areas such as computer operation, hardware and software design, sales, programming, repair and maintenance are, and will continue to be, in demand in the Northern Territory.

"Equal Bytes" was produced for the Women's Bureau by Film Australia with assistance from the Commonwealth Employment Service.

COMPANY NEWS

In a major management restructure, OTC has appointed three new divisional general managers — Peter Meulman (technology), Chris Vonwiller (corporate) and John Randall (finance). Two further key positions are yet to be filled, for operations and human resources.

Amtex Electronics has been appointed as a distributor for Yuasa sealed lead acid batteries. The company will concentrate on the industrial electronic market.

Measuring & Control Equipment Co Pty Ltd (MACE) has moved its Sydney head office and laboratory to new premises at 14 Glen St, Eastwood, NSW 2122. (02)858-5800.

Ferguson Transformers has moved to a large, modern factory at 7 Moorebank Ave, Moorebank, NSW 2170. (02)602-1222.

Also on the move . . . Dick Smith Electronics' Brisbane city store is now at 157-159 Elizabeth St, Brisbane, Qld 4000. A new DSE store has also opened at the corner of Kingston Rd and Pacific Hwy, Underwood, Qld 4119.

RACAL has announced a new company structure. It will now operate as a single data communications company called RACAL-Milgo. All distribution and service will be centrally controlled from the Sydney head office.

Intel strategy

In an effort to return to its preeminent position as a semiconductor memory chips manufacturer (before the great Japanese market takeover) Intel has established a new 6″ wafer plant in Alberquerque, New Mexico, optimistically called Fab 7.

Expectations were that the plant will be exceptionally more productive than usual due to the introduction of 12-hour shifts with alternating three and four day weekends. Workers apparently overwhelmingly welcomed this. So far the success of this plant is indicated by Intel's move to establish another plant next door. The new plant is also the result of partnership with a Japanese concern.

Along with the new manufacturing plants, Intel has set up an R&D program which has been successful in producing a parallel processor, finished last July and reportedly functioning well. Industry analysts are, however, sceptical about any US company's move against the huge Japanese firms. The prediction is that by the beginning of this year, Japan should have 18 of the 24 facilities handling 15.24 cm wafers — which was really the product behind the Fab 7 establishment.

Picture phones next, says Arthur C. Clarke

A telephone call via satellite from London to a ship in the South China Sea late last year marked the 40th anniversary of the mooting of communications via space.

Author, scientist and futurist Arthur C. Clarke first explored the possibility of using satellites stationed over parts of the Earth to provide a new means of world-wide communications in 1945, in an article published in the magazine *Wireless World.*

Today the magazine is known as *Electronics and Wireless World* and its editor Philip Darrington paid tribute to Mr Clarke's farsightedness by using the very system he advocated to talk to Clarke on board a ship travelling from Hong Kong to Colombo.

The call was made from the London headquarters of the International Maritime Organisation (IMO) to the coast Earth station at Eik in Norway, from where it was beamed via an Intelsat satellite stationed above the Indian Ocean to the SS *Universe.* The ship received the call on a dish aerial about one metre in diameter. This tiny antenna is specially stabilised so that it is always pointing at the satellite regardless of the ship's course or movement.

Mr Clarke says he has been surprised at the speed of satellite communication developments. When he first put forward the idea he thought it would materialise nearer the end of this century. But in the short period since the mid-1960s, hundreds of satellites have been launched into the 'Clarke' orbit or geosynchronous orbit whereby the satellite revolves with the Earth staying at the same place above one of the three major oceans and forming a chain capable of relaying telephone calls or TV pictures to any part of the world.

Geosynchronous satellites have now become the world's dominant medium for long-distance communications. About two-thirds of the world's overseas communications are carried via satellite and almost 4000 ships, oil rigs and other vessels are now on call to their bases from anywhere in the world via a satellite network operated by the London-based International Maritime Satellite Organisation (INMARSAT).

Mr Clarke believes there are immense possibilities in space still to be explored. One of the next developments could be picture phones enabling people to see one another when they speak to each other via space.

BRIEFS

Money movers

Australia's first exhibition of technology, equipment and services for the financial and retail sectors will be held at the Melbourne Exhibition Building from 18-21 February. It's called Finance '86.

High tech gift for TAFE college

When Siemens Ltd staffer Mike Ryan did a short course on programmable controllers at Melbourne's Footscray TAFE, he noted that his company was not represented in the teaching equipment. Siemens has since presented the college with goodies worth $1700.

China's labour minister visits Labtam

A representative of the Chinese Government, Mr Zhae Dongwan, minister of labour and personnel, recently visited Labtam International. Labtam is participating in a joint venture with the Chinese Academy of Science to develop a mainframe computer running both English and Chinese software.

Backing for Electrodata

With a $400,000 investment, First MIC Limited has secured a 30 per cent interest in Electrodata Associates Pty Ltd, which designs, manufactures and markets communications recording equipment from a plant in Mortdale, NSW. First MIC is managed by Hambro-Grantham and its shareholders include the Commonwealth Bank, City Mutual Life, STC and Mitsui.

AWA in defence bid

AWA has teamed with defence contractor Signaal of Holland to tender for the Project Definition Study (PDS) Navy contract to design a combat system for Australia's new $2.6 billion submarines. In the initial phase of the bid AWA engineering manager Bill Carter will spend 12 months with Signaal engineers in Holland.

FAX for Grand Prix news

While drivers were speeding around the circuit at last year's Adelaide Grand Prix, another race was being run in the official media centre between four Voca-Fax 7200 facsimile machines and 15 telex terminals. The popularity of the fax system among journalists so impressed the organisers that they have asked Voca to submit a communications proposal for this year's event.

Big design centre

Ericsson has opened a three-storey design resource facility at Broadmeadows, Vic, to house one of Australia's biggest potential electronics export projects — an AXE rural exchange communications network which involves the company in a partnership with Telecom.

Plessey ISDN network for NRMA

Plessey Pacific has announced that it expects to receive a $4 million order from the NRMA for an ISDN telecommunications network. Comprising 24 integrated services digital exchanges (ISDXs), it will be the first private link-up of its type in Australia.

Project 751, Miniature FM transmitter, December '85: What could go wrong with this one? A typo. The equation for the turns ratio in the How it works section (p 50) should be: $N = k\sqrt{\frac{Ro}{Ri}}$

The Sound of Nakamichi

Next time you audition stereo components,
close your eyes and concentrate on the sound of music.
Don't be surprised to find that most electronics
sound the same. They do! Now listen to the
Nakamichi ST-7 AM/FM Stereo Tuner, CA-5 Control
Amplifier and PA-7 Power Amplifier.
Hear the difference? The clarity? The transparency?
Nakamichi electronics *sound* better because they're
designed better. Unlike ordinary power amplifiers
that rely on "feedback" to lower distortion,
the PA-7 STASIS circuit generates negligible distortion
without using global feedback. The ST-7's Schotz
NR system helps it reach out farther and pull in
distant stations cleanly and quietly.
And, by eliminating unnecessary circuitry and controls, the
CA-5 ensures you the ultimate in sonic purity.
Step out of the ordinary . . . Step up to
The Sound of Nakamichi.

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ETI READER SERVICE 103

Letters to the Editor

Sound science

I AM AN irregular reader of hi-fi advertisements and over the past year or two some of the ads have provided me with much interest.

The highly scientific information with which some companies sell their wares has been a continual source of mystery to those of the engineering profession. After all, we only received an ordinary sort of education.

We used to think that amplifiers were needed to "boost car sounds". Apparently, a piece of wire ("Hotwires") can now do it. Is this the amplifier engineer's dream come true — a piece of wire with gain?

Cheap twin-core flex rated at 7.5 amps is no good anymore. Toss it out. Buy yards of special cables at exceptional prices to make your music sound better.

Loudspeaker stands also come under question. Not just any speaker stand will do, although simple arithmetic suggests that the effect of special stands is non-existent. But these are merely imperfect engineering calculations!

Appended is a diagram of a controlled experiment to determine the sonic integrity of a loudspeaker stool to settle the question once and for all.

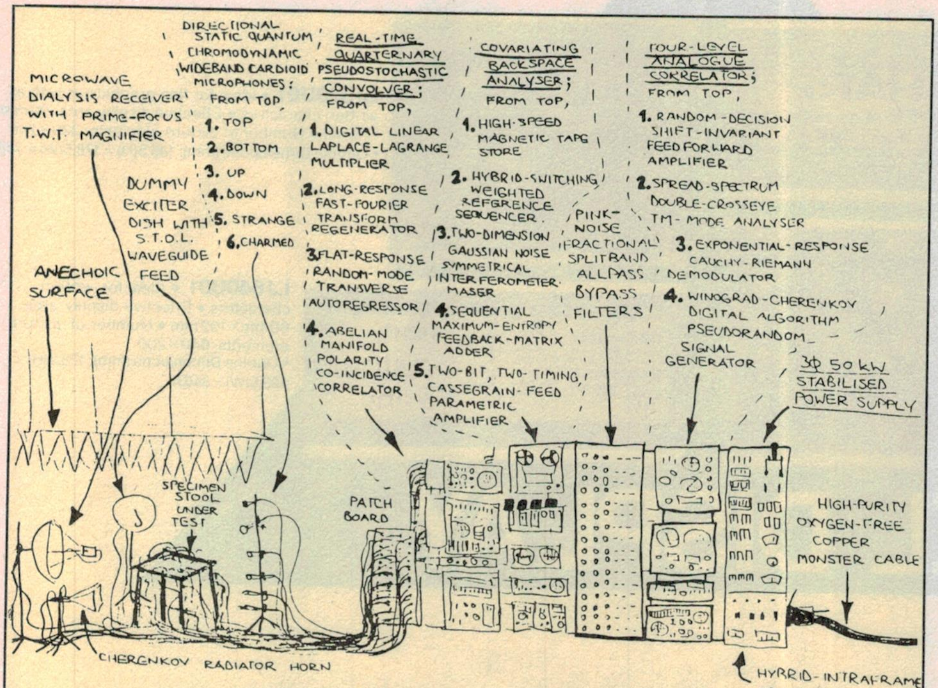
By now we are really out of our depth, including the PhDs among us. Could the proponents of special turntable cones (stands) also explain how they improve the "sonic purity" of an electric current issuing from an amplifier, which is essentially a box of solid metal, plastic, fibreglass, solder and silicon? For decades engineers have been devising ways to isolate gramophones with sophisticated suspension to reduce vibration transmission. We have been barking (woofer, woofer) up the wrong tree. The thing, according to experts in "sonic purity", is to do the opposite: "mass couple" the thing to the shelf with these cones, making the "pressure per square inch [?] . . . enormous, thus coupling the component to the surface as solidly as if the component had far higher mass".

Brilliant! I shall go two steps better. I will ballast my amplifier with bricks for better bass definition and bolt (½") my gramophone down with ¼" angle irons instead of fitting a fenestron to counteract the torque reaction of the rotating platter.

Ruminating over this elegant new invention, I perceived another use for these cones. By fitting their shoes with them, opera singers will be able to "achieve a clarity, resolution and dynamic range [they] never thought possible".

It would be interesting to see whether the proponents of "sonic purity" would be brave enough to put their extravagant claims, "expert knowledge", "vast experience" and miraculous ears to the test of controlled experiments and let us know the outcome.

Y. Dudinski,
Sunshine, Vic 3030



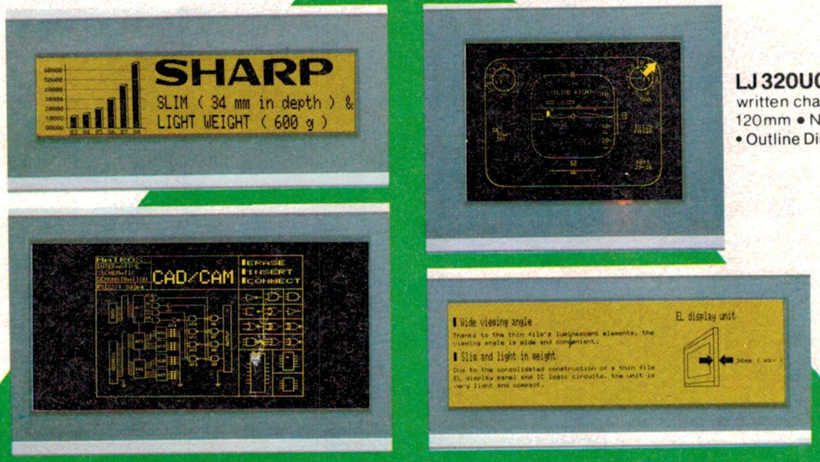
CONTROLLED EXPERIMENT TO DETERMINE THE SONIC INTEGRITY OF A LOUDSPEAKER STOOL

25 LINES OF 80 CHARACTERS!
FLAT PANEL DISPLAYS AVAILABLE NOW!!

This is the actual effective display size of LJ512U05

Sharp's full line of EL (Electro Luminescent) Displays are thin (34mm), lightweight (650 grams), low power (15 watts max) and the two latest editions can display 25 lines of 80 characters. These "State of The Art" Displays feature; line by line scrolling, blinking characters, full graphics and a simple 4 line interface. EL's bright, crisp, easy to read characters will enhance the marketability of any product.

Design the leading edge of display technology into your products today using displays from Sharp, the world's largest manufac turer of EL Displays!



LJ512U01 • Ideal for written characters • Effective display area: 44.8mm×179.2mm • Number of picture elements: 512×128 • Outline Dimensions (mm): 108.5(H) × 228.5(W) × 34(D)

LJ320U01 • Ideal for fine graphics as well as written characters • Effective display area: 90mm×120mm • Number of picture elements: 320×240 • Outline Dimensions (mm): 148.5(H) × 178.5(W) × 34(D)

LJ512U05 • Ideal for fine graphics as well as written characters • Effective display area: 96mm×192mm • Number of picture elements: 512×256 • Outline Dimensions (mm): 148.5(H) × 228.5(W) × 34(D)

LJ640U01 • Ideal for written characters • Effective display area: 60mm×192mm • Number of picture elements: 640×200 • Outline Dimensions (mm): 108.5(H) × 228.5(W) × 34(D)

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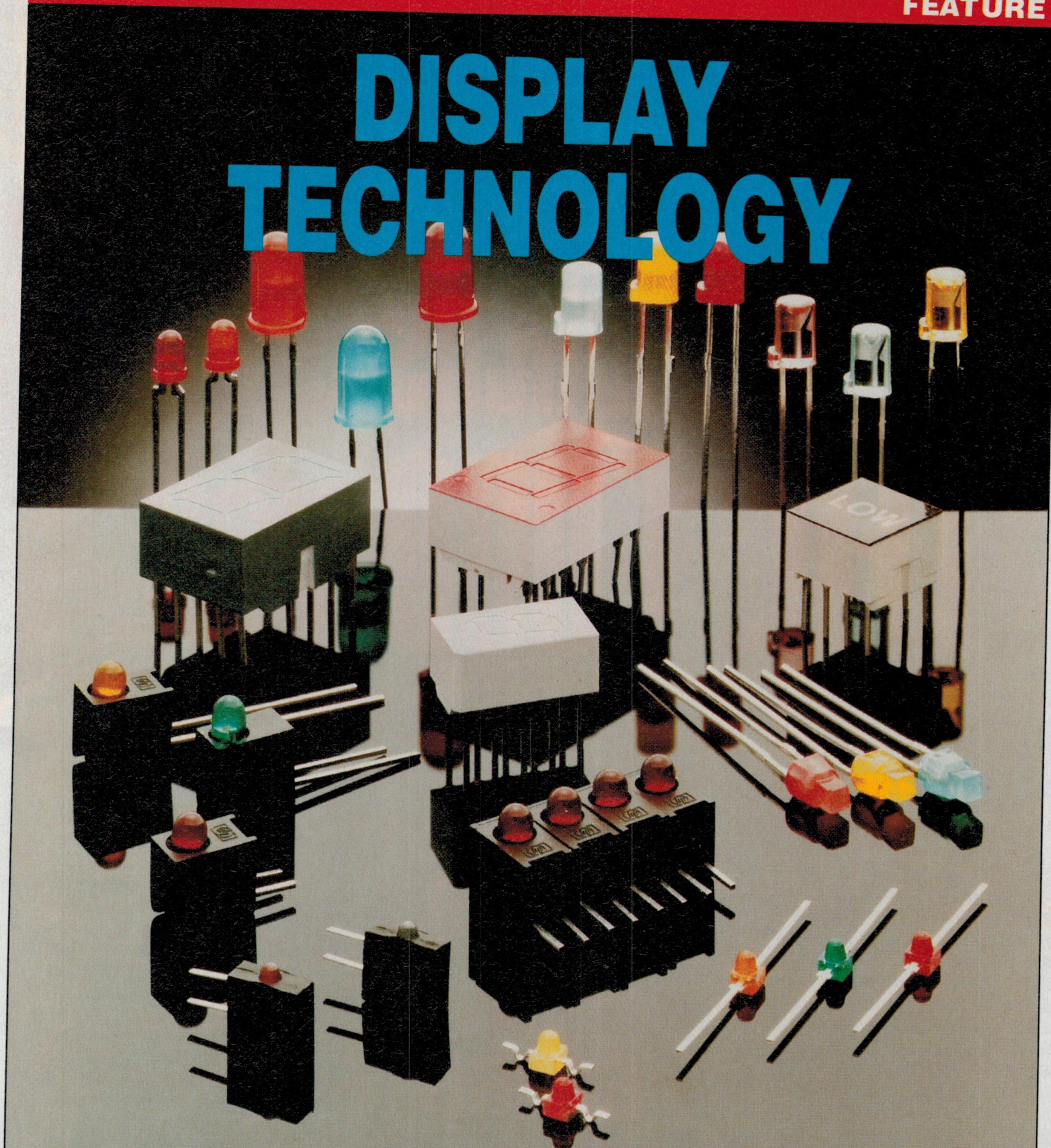
DISPLAY TECHNOLOGY



Jon Fairall

Not so long ago a display to meant just one thing: the cathode ray tube. Today, on the crest of solid state rides a much wider choice. We trace developments and advantages, in this new technology — but somehow never lose sight of the CRT.

THE WONDERS OF computing would be useless without the ability to communicate across the computer/operator interface. In many respects it's the most difficult, as well as one of the most interesting, challenges of modern electronic design, and as a result speech synthesis and voice recognition are all the rage in labs around the world.

However, much of the information human beings get about the world is visual. Honed by millions of years of evolution as tree-swinging, hunting ape-men, our visual faculties are far more sensitive than any of our other senses. Our brains are wired to organise visual information far more quickly and readily than any other type. A picture, they say, is worth a thousand words.

Learning to talk to computers is important, but loudspeakers will never replace the display screen as a means of getting information out of them. The problem though, is to refine our methods of so doing. To an extent it's a software problem: making the displays easier to understand, getting more information out in less time. But it is also a hardware problem. Making displays easier to read, making them lighter, smaller (or bigger), above all making them less expensive in terms of manufacturing and power requirements.

This story is about the technology of the computer screen, about LCDs, tubes and plasma screens. It's about trends in the display industry and what's likely to happen in the next few years.

Types

The place to start is probably with the most humble device of all, the LED. Light emitting diodes are simple to use and very cheap, and still used widely to monitor the state of individual lines. A step up in sophistication is the segment display, which is typically fabricated using monolithic techniques akin to integrated circuit manufacture. Another method of construction is to mount an LED on a reflecting surface to give a bar display. Typical layouts include the seven segment LED used to denote the numbers 0 to 9, and the 14 segment display used to denote alphanumerics. Both these types are still used extensively where the output requirements are very simple and where cost and simplicity are vital considerations.

The LED has one problem however, and that is that it takes a fair bit of current to drive it, typically several milliamps. That's not much by itself, but as soon as the display gets a little more complex it becomes a factor of overriding significance.

A considerable amount of effort has gone into solving this problem. Industry-standard ways of multiplexing have been developed for instance, which allow a designer to drive, say, half a dozen seven segment displays, using multiplexing based on standard TTL chips like the 7447, that can be purchased for a few cents.

Such techniques afford considerable savings in terms of power usage, but they can't be extended sufficiently far to allow LEDs to form part of practical computer display panels. For instance, if one assumes a typical LED might consume 10 mA, it seems that a display of 600 x 400 pixels would consume 20 A. There would also be heating problems.

Unfortunately for the LED, dot addressable display panels are increasingly where the action is. The complexity of a graphics-capable display is becoming the standard for displaying reasonably complex information quickly in a way that a human being can absorb. A second reason is probably more cultural than technological. The oriental characters known as Kanji, much beloved in China and Japan, are far more complex than our own occidental character set. While the Japanese have been reasonably content to live with our letters for the last twenty years, the Chinese, one quarter of the world's population, are less amenable to change. The lesson being read in display headquarters around the world is if you want to get into China, get with the dots.

CRT

Of course, one technology is already into dots, indeed, it's all it can do. The CRT is still the most significant type of panel display technology (see box). It's an example of the vacuum tube technology that founded modern electronics. With the exception of high power transmitter valves it is the last great hanger-on from that era. It's big, it's heavy, it's clumsy. In terms of screen brightness and resolution it is still quite unbeatable however, and so remains unchallenged in areas where such things are important.

And of course, such areas are plentiful. The cathode ray tube is the only practical technology that can cope with the wide ambient light conditions required for a domestic TV set. Thomas Electronics, one of the biggest tube sources in Australia, has just ▶

Historically, the first important method of interfacing a man to a computer was via a cathode ray tube (CRT). Until comparatively recently it was the only wide screen display device in existence.

How does it work? A typical CRT consists of an electron gun, various control grids and a screen. The screen is covered in phosphor, a material that will emit light when bombarded with electrons. The function of the gun is to produce a stream of electrons, called the electron beam, which is shot at the screen. It does this by heating a conductor, called a cathode, in a vacuum chamber. Normally, when a conductor heats up, it liberates quantities of negatively charged electrons, which lose their excess energy by collision with atoms in the atmosphere.

However, when the cathode is heated in a vacuum, this mechanism no longer operates. The result is that the electrons, all negatively charged, will start to move towards the nearest positive charge. If this is made to be the screen itself, the electrons will fly off the cathode and head towards the screen.

The velocity of the electrons is determined by the potential difference between the cathode and screen. The bigger the potential the faster the electrons fly, and it is no very difficult matter to make electrons move at an appreciable fraction of the velocity of light in this fashion.

Velocity is of interest because of the relationship between the electron's velocity and the amount of light given off by the phosphor when it gets hit by an electron. Once again, the bigger the better. The faster the electron is moving, the more energy it has, the more it can transfer to the phosphor, the more light the phosphor will emit.

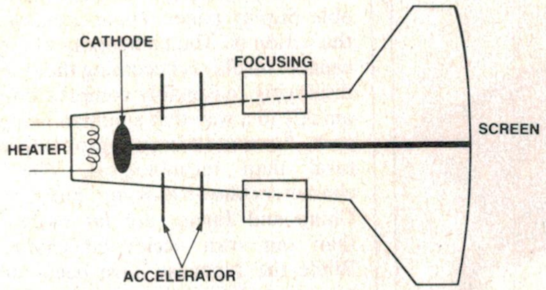
A practical tube is a bit more complex than this. For a start there will be accelerating grids down the side of the tube, with their potential arranged so that they accelerate the electrons on their way. There will be a focusing grid, so that the beam illuminates as few phosphor particles as possible at any one time, and, last and most important of all, there will be a control grid, the purpose of which is to deflect the beam.

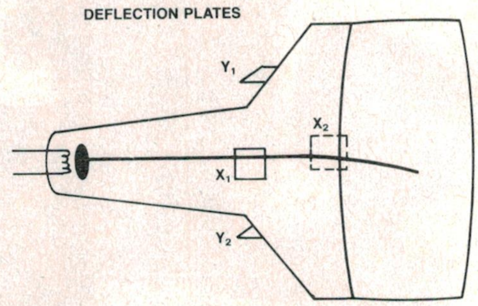
The place where the beam strikes the screen is controlled by the control grid, often known as a deflection plate or the yoke. It does this by imposing a voltage across the tube at right angles to the beam. If things are organised correctly the beam can be bent to strike any part of the phosphor screen at the front of the tube. Normally, things are arranged so that the control yoke consists of two separately controllable elements, the x plates and y plates. One pair will move the beam up and down, the other from side to side.

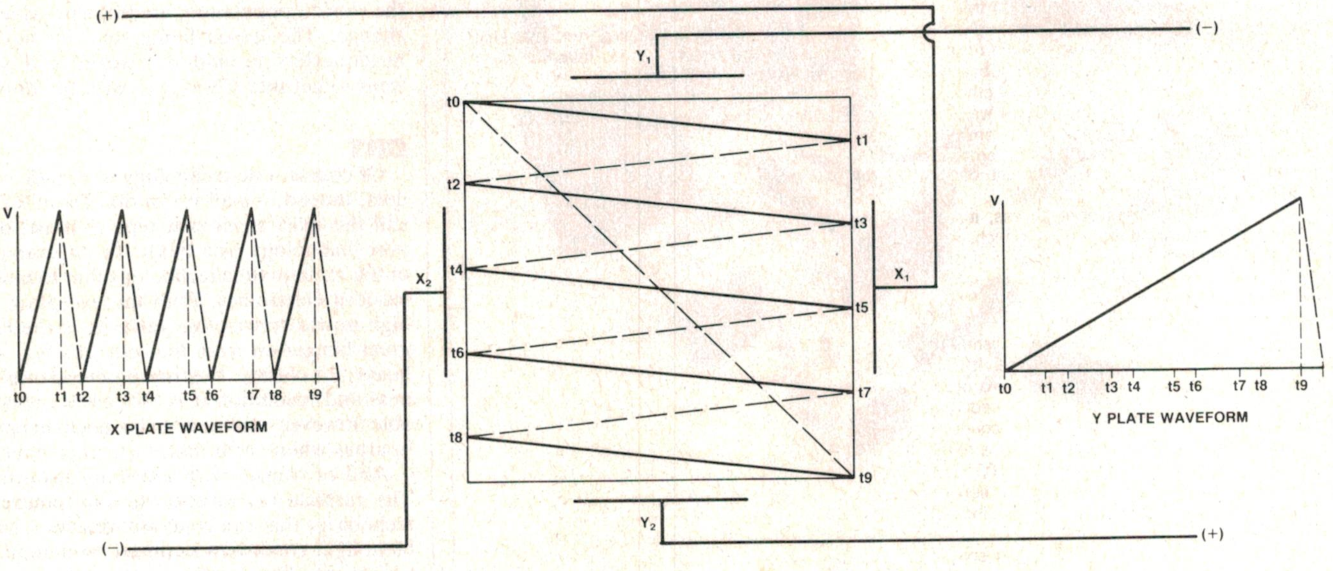
If a sawtooth wave is applied to the y plates, the wave will move relatively slowly from one side to the other, and then fly back to its starting point before repeating. The size of the voltage applied to the y plate at any instant will be precisely related to a specific spot on the screen. If a similar wave form is applied to the x plates the beam will move up and down. Now, if these two wave forms are applied together, with the y plate voltage having a frequency much faster than the x voltage, the beam will trace out a series of lines on the screen. The number of lines will depend entirely on the difference in frequencies. If the y voltage runs twice as fast as the x there will be two lines on the screen, both sloping downwards strongly. If the y voltage is about 300 times x, which is more or less the situation in a TV set, then there will be 300 lines and the slope of the lines will be imperceptible.

To make a usable display there are only two other things to consider. Firstly, it must all happen quite quickly. Remember that only a single spot on the screen is illuminated at any one time. To make lines appear the dot must travel very quickly. In fact it turns out that if you cover the entire screen in 1/30 of a second, the illusion of a screenful of lines is created. This is known as a raster.

A raster, wonderful though it is, is of very little use to anyone. It conveys no information. To do that we need modulation, ie, the ability to change the intensity of the beam. With modulation, we can turn the beam off so that a black screen results. Then, when the beam reaches a certain spot, we can turn it on, then off again. If this is repeated over and over again, at a sufficiently high frequency, a single dot will appear on the screen. No prizes for guessing that timing is critical. Do it many times, and arrange the dots in specific patterns, and the result is a symbolic array, letters, numbers, lines, whatever.







received a contract to put CRTs into the F18 fighter for the RAAF. In the US, NASA specifies them for the space shuttle and in Europe they are all the rage in airbus cockpits. There is nothing old fashioned about the tube.

Not that tube designers are sitting on their laurels. Tube makers point to improved resolution for instance, and to new folded screen technologies such as those developed by Sinclair Research in the UK as improvements in the product.

However, the CRT suffers from some considerable disadvantages that have affected the design of its host system for far too long. For instance, in most applications a separate power supply to derive the high voltage is required. Because it requires a vacuum for efficient operation, the glass needs to be thick and heavy. The problem is exacerbated by the need for a large flat panel at one end to use as a viewing screen. Typically it can be ¾ of an inch thick, reducing to ⅛ of an inch at the neck of the tube. This requirement has implications for weight also.

As well as these electromechanical problems, fears have been expressed about health problems associated with CRTs. As computers have become more prevalent in the workplace, and more people have come to spend ever longer in front of computer screens, an epidemic of eye disease and nervous disorders has raged in offices. These health allegations can usually be divided into two kinds: those arising from ergonomic factors such as glare and flicker, and those that come from radiation.

Evidence has been tendered that shows an alarming incidence of eye problems in people who habitually spend time in front of VDUs. The argument is that staring at a flickering screen, full of annoying reflections from the surrounding area, probably with insufficient contrast between the characters and the background, does terrible things to your eyes, especially when you have to do it for hours on end. If it doesn't cause eye strain, it may well cause skeletal problems in the operator, who twists and turns into strange positions trying to alleviate the problem.

As a result a considerable amount of work is going into reducing glare. This includes the development of anti-glare layers bonded directly to the front of the screen, which are designed to cut out reflections from the surroundings and improve contrast.

There is also a great deal of interest in examining the position of the worker in relation to the keyboard and the screen, to see what effects this might have on posture.

Radiation from the tube is also alleged to be a problem. It's generally argued that X and gamma ray emission can cause a variety of complaints, including malfunctions of the reproductive system. However, in spite of a considerable amount of investigation, no really satisfactory statistics have been produced which show a correlation between any disease and exposure to radiation from a CRT. "I know it sounds trite, but it's true that you do get more radiation from the sun on a warm day than from a CRT", says Phil Kelly of Thomas Electronics.

Nevertheless, constant exposure, eight hours a day, day after day, might be a problem. Certainly, the issue will not lie down and go away in spite of assuring noises from tube manufacturers. It's just another thing that makes alternatives look attractive.

LCD

The biggest challenge to CRT technology is coming from liquid crystal displays. LCD technology was responsible during the seventies for the creation of a whole new industry around digital watches and portable calculators. During the eighties it has been responsible for the introduction of portable computers.

Liquid crystal starts with some tremendous advantages. It lends itself naturally to a flat compact screen which weighs little. It's a passive device, not dependent on emitting light, and as a result its power requirements are extremely low. A Melbourne manufacturer, Consolidated Technology, claims a current requirement of 20 nA per square mm at 5 V. In fact, LCD elements can be driven directly by CMOS logic.

From a manufacturing point of view the flexibility offered by LCDs is enormous, since the pattern of displays can be altered simply by changing the electrode masks. In fact, according to Consolidated Technology, production runs of as few as 500 units are quite viable.

This has enormous implications, not only for small manufacturers, but also for large manufacturers considering rather small production runs. Philips, for instance, has designed car dashboards composed entirely of LCD elements customised to the requirements of the particular motor vehicle. The days of the standard speedo are numbered.

However, liquid crystal is still a very immature technology. It suffers badly by com-

LCDs

The story of LCDs goes back to 1888 when an Austrian named Reinitzer observed that a chemical brew called cholesteryl benzoate has some rather odd characteristics. When it's heated, the solid benzoate melts to a milky liquid, which, as the temperature is increased still further, clears to become transparent.

Chemists call the different states of a substance, whether solids, liquids or gases phases. It was shown that this milky phase of the benzoate had some rather odd optical characteristics. In particular, it was doubly refracting. This is a phenomenon often seen in a crystal, but never in a liquid. As a result, the substance became known as liquid crystal.

It was discovered that the crystal-like behaviour of cholesteryl benzoate is due to the fact that the liquid phase has a rod like structure in which the molecules group together in an ordered manner. In an ordinary liquid the molecules are completely unordered. A few other effects were established. For instance, it was discovered that liquid crystals have different optical and electrical characteristics in different directions, depending on the alignment of the rods in the crystal.

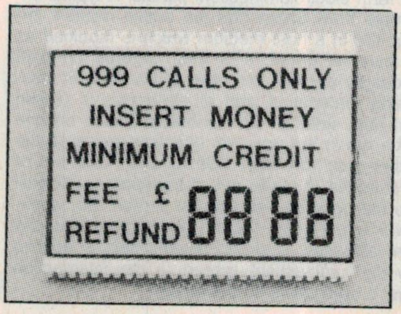
However, having discovered all this, it was put on the shelf. Not good for very much, they said. It wasn't until the 1960s, and the advent of microelectronics, that someone remembered the esoteric little light switch discovered long ago by an obscure Austrian.

In 1971 Schadt and Helfrich published a paper on the 'twisted Nematic' effect. It was really rather simple. Firstly you need two glass plates. The inside of each plate is coated with ITO, indium tin oxide, an electrically conducting, transparent material. Then you put a really thin layer of liquid crystal next to the ITO. The ITO can be used to apply an electric field to the liquid crystal so that the crystals line up along the field.

Schadt and Helfrich put a polarising screen on the outside of the glass panels, thus making the screen transparent only to light waves vibrating in the plane of the polarised layer. They oriented the field in the same direction, thus lining up the crystals in the same plane as the polarisation. One would expect that if you put two such panels together, with their polarisation at 90 degrees to each other, the composite panel would be opaque. However, they discovered that, in fact, what happens is that the two liquid crystal layers coalesce into a film, in which the crystals slowly twist from one plane to the other. As they do so, they twist the polarisations of the light as well. So, the two panes of glass, each polarised at 90 degrees to the other, pass almost all the light that falls on them.

The key to all this is that if an external field is applied to the crystal, all the rods will align themselves to it. The crystal film will lose its twisted structure, and the polarisation of the two panels will assert itself. No light will be transmitted.

From here it was but a short step to shaping the ITO layers into segments and forming a useful display. Applying a tiny amount of current to any bit of the ITO then causes the screen above it to become opaque.



parison with CRTs when it comes to resolution, and as a result no really satisfactory dot displays have yet been produced although many manufacturers have made claims to the contrary. The problem is one of fabricating a small enough dot, while still keeping contrast at acceptable levels.

The other big challenges for LCD manufacturers in the near future are the introduction of colour screens and developing technology to make the screens bigger. Colour screens are well on the way — in fact Casio put out a portable TV with a colour LCD screen at the Summer Consumer Electronics Show in Chicago in July last year, and Sanyo has announced a large wall hanging display.

However, there are still lots of problems with colour LCDs. Usually it works with a 'host-guest' system, ie, a special dye is mixed in with the liquid crystal 'host' and moves with it. But the dyes are not particularly stable over time, especially when exposed to sunlight. Also, drive requirements are much higher for this type of display, limiting its usefulness in portable applications.

A possible solution is to combine LCDs with LEDs. LM Ericsson, for instance, uses LEDs as a backlight source for the LCDs in some of its displays. However, this option is only available in character displays.

Another set of problems that plagues LCD screens relates to the viewing angle and the brightness of the screen. Since the screens depend on light being passed through them they depend on the ambient light level. Usually, a reflective layer is positioned behind the screen, so that ambient light will reflect back. In bright sunlight they are fine, but in the dark problems emerge. Illuminating the screen indirectly, say with an incandescent light on the side as is done in wrist watches, is not a very elegant or efficient solution for large displays. A better answer is to put a fluorescent sheet behind the display.

Another problem is that the operation of the system depends on the cholesteryl benzoate being in its liquid form (see box). This has been solved to all intents and purposes by judicious mixing of chemicals. Modern screens can withstand −10° to +60° Celsius. If that is not enough, special mixtures are advertised for use from −30° to +85°C, more than the human operators could withstand in all probability.

Plasma

The plasma display panel (PDP), goes a long way towards solving some of these problems. It is extremely bright and can be viewed from any angle. Compared to a CRT, it is light, thin and easy to handle. ▶

ELECTROLUMINESCENT SCREENS

Natural luminescence was discovered in 1603 by an Italian alchemist called Cascariolo who had nothing better to do with his time than grind up rocks to see if he could turn them into gold. He didn't, but he did discover that if he took a special kind of stone that was common locally, and heated it with coal, the embers would glow long after they were cold. He called the material 'Lapis Solus' or sun stone. We call it barium sulphate and represent what he did with:

$$BaSO4 + 2C \rightarrow BaS + 2CO2$$

The BaSO4 was the original stone and the carbon was supplied by the coal.

It is important to realise that luminescence is very different from incandescence. The latter happens because of heat, as in a light bulb. The former does not require heat at all, but is the result of a chemical process happening in a cold body. It seems that in certain substances, a proportion of the total population of atoms in the substance will have a higher than normal energy level. Modern quantum theory predicts that this situation will be unstable, and that each of these atoms will try to jump down to its 'ground state' or state of lowest energy. As they do so they release energy, and this is often detected in the form of electromagnetic radiation, some of which is in the visible part of the spectrum.

It took until 1923 to discover that this phenomenon could be effected in certain materials by electricity. Particular crystals could be made to glow if a large potential was placed across them. The energy absorbed by the crystal was liberated at the frequency of visible light.

In modern structures this technology is used to form electroluminescent panels. A typical example from Sharp has the active crystals implanted in a host medium which is moulded as a thin flat panel. It is then covered on both sides by another thin layer of transparent insulating material. A grid of electrodes is placed on both sides of the sandwich. Those on one side run in the up-down direction, those on the other side run from side to side. One set of electrodes is made out of transparent material so the operator can see the screen. So, whenever a particular column and a particular row are activated, a strong electric field is applied to the luminescent screen at the intersection and a spot glows on the screen.

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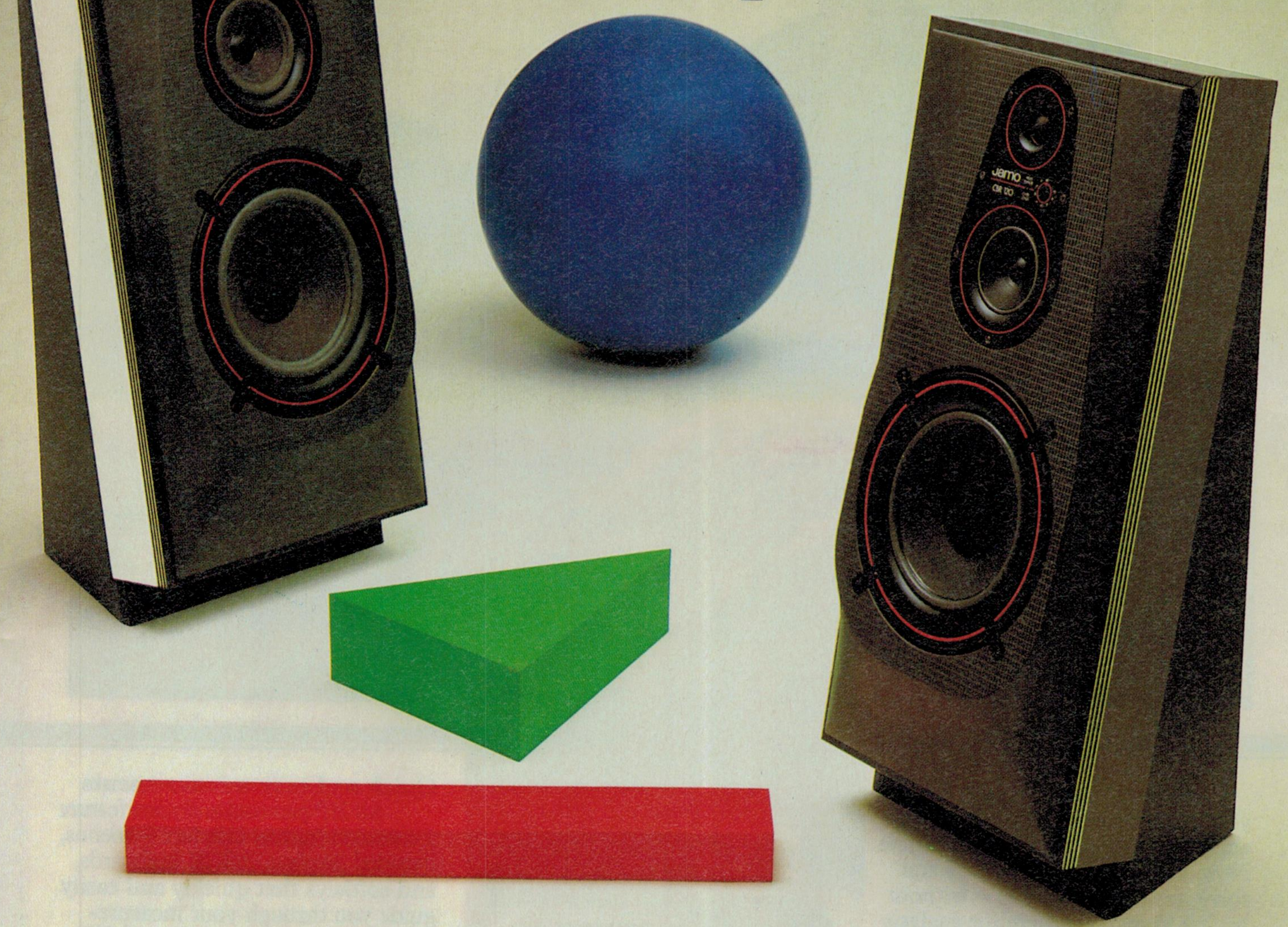

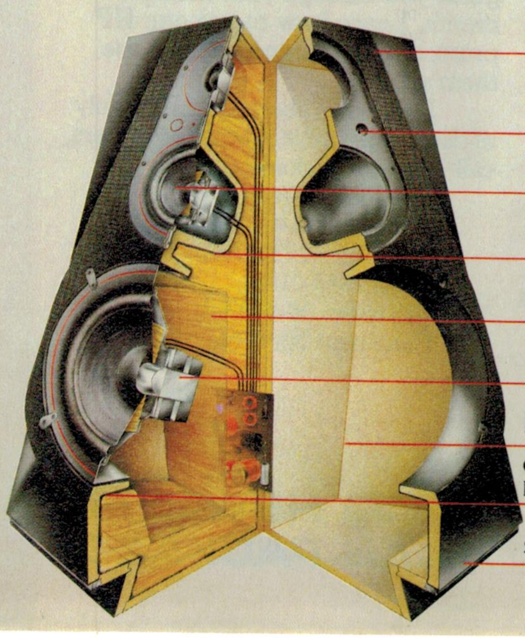

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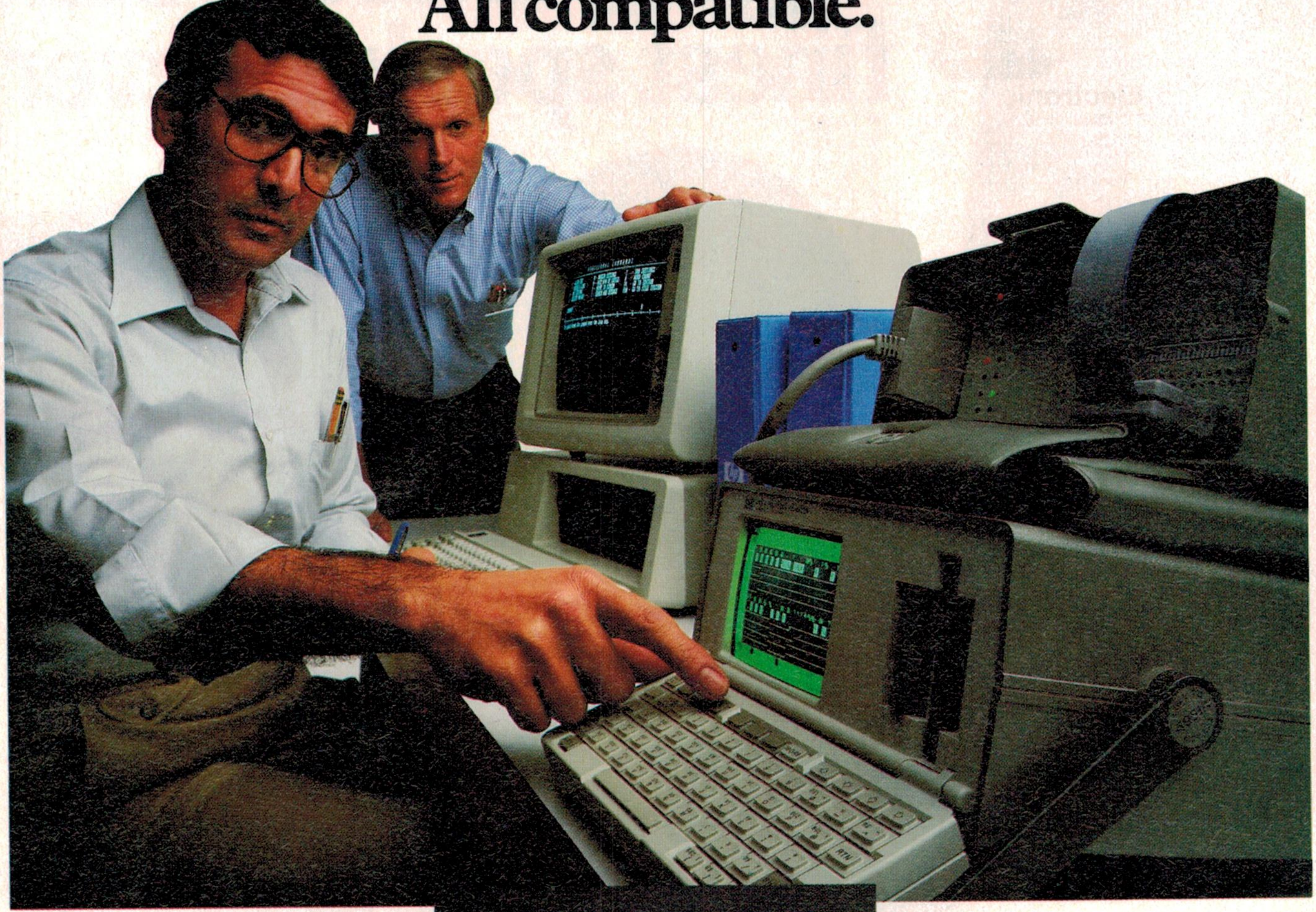

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HEWLETT PACKARD

PLASMA SCREENS

Plasma screens are a relatively recent invention, although the basic technology has been known for many years. A practical plasma display panel (PDP) is composed of a very large number of extremely small cells. A typical panel from the Japanese manufacturer OKI consists of 640 x 400 pixels in a 211 x 132 mm screen. Each dot is about 0.2 mm in size.

A plasma display is a kind of cold cathode gas discharge tube in which a large potential is created between the anode and cathode in the presence of a rare gas. This ionises the gas, ie, creates a plasma. The plasma liberates energy in the form of electromagnetic energy. Thus the light lasts as long as the voltage is supplied.

The gases involved are mixtures of neon and argon or xenon. These gases are usually mixed together because it is found that a trace of argon or xenon in the neon reduces the voltage needed to create the plasma. Other factors affecting the light output are gas pressure and the distance between the electrodes.

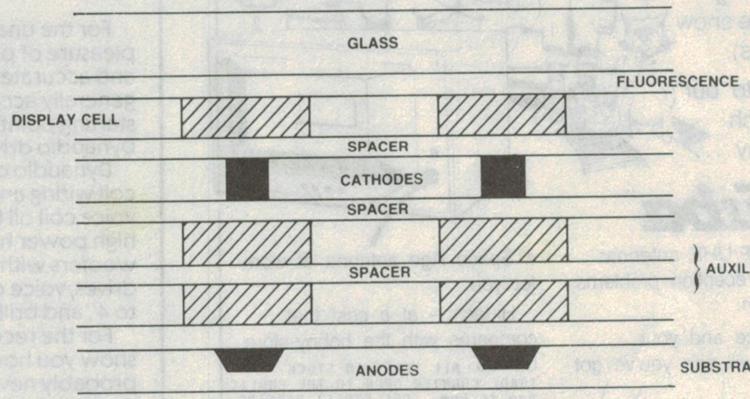
In fact, a practical PDP is rather more complex than this outline would suggest. Typically, the anode and cathode are laid out in a matrix. Each consists of long thin conductors imbedded in glass substrates. The gas is contained in tiny tubes at each intersection, divided in three to form separate cells. Above the cathode, towards the front of the panel, is the display cell. When it gets excited, this cell will emit ultraviolet radiation, which in turn excites a fluorescent layer on the glass, thus creating visible light.

Below the display cell, between the cathode and anode, are the auxiliary cells, consisting of the constant discharge and scanning cells. It is these cells that actually use the anode-cathode potential. The constant discharge cell functions much like a capacitor, and is used to supply a constant stream of electrons and ions to all its neighbouring display and scanning cells to pre-bias them. The scanning cells act to transfer this mechanism from left to right across the screen, hence their name. This is necessary because it would take too long to turn the display cells on from cold, and so a flickering panel would result.

In order to make a dot illuminate, it is necessary to make a particular cathode go as low as possible and a particular anode as high as possible. When the potential between them rises to a certain level, called the firing level, ionisation starts in the auxiliary cells at the intersection of the electrodes. Ionic transfer then excites the display cell which causes a dot to glow on the screen.

To keep the dot on it is not necessary to keep the voltage at the firing level. Discharge can be maintained with a considerably lower voltage, called the maintenance voltage. In practice then, the voltage waveform on the anode consists of a step function in which a sharp spike rises above the firing level and then sinks to a back porch which maintains discharge for the required length of time.

Because of these and other requirements, plasma panels come with their drive circuits on board. A designer seeking to integrate such a unit into his or her device need only supply TTL data and timing signals. These are then buffered to voltage levels required by the device. Some units have on-board character generators made out of a bit of ROM. This simplifies the design task even further, since it is then possible to talk to the display in ASCII or some similar code. Of course, such an approach means that each pixel is not addressable by the user, so graphics is not possible, but in many applications the saving in complexity outweighs the disadvantages.



However, PDPs are far from being a perfect display vehicle. They are still monochrome in spite of the best effort of physicists, and the trade off for the bright screen is a distressingly high supply voltage. A typical anode voltage is 250 V for an orange screen; 280 V for green. Current flowing through the discharge cells can peak at 500 mA.

Price is another problem. The Japanese manufacturer OKI advertises screens at about twice the price of a comparable CRT. However, this situation is not likely to last indefinitely, because a plasma screen is intrinsically cheaper than a CRT. The present high price probably reflects manufacturing difficulties more than anything else, which may be expected to ease over time.

Drive

One advantage solid state devices have over the tubes is that they frequently come with integrated drive circuitry on the back of the panel. Early generations used separate monolithic devices like TTL multiplexers, LED drivers and decoders which could be connected to the device by the designer. The modern trend is to integrate the display totally with the drive circuitry using so called chip on glass techniques.

Chip on glass means pretty much what it says. The bare chips, ie, silicon substrate, are bonded directly on to the glass panels of the display. Connections are made by drawing fine gold wires across the glass to the required contact points on the display. The control inputs, which will accept display instructions from the host device, are taken to an edge connector or socket on the side.

The philosophy here is to make the device as easy to drive as possible. The need for the designer to consider expensive or difficult design decisions is removed. He simply treats the panel as an output port to which a stream of ASCII or binary symbols can be addressed.

Future developments

The future is probably with solid state panels for they have on their side size, weight and economics. However, the tube manufacturers are not about to give in without a fight. Over the last five years the quality of CRTs has improved considerably and will probably continue to do so.

The result is that the solid state screens are presented with a moving target. The difference between the best resolution obtained with tubes and with flat screens has actually widened over the last few years. Designers of solid state screens still have real problems to overcome in terms of brightness and contrast, not to mention colour.

In the nature of the case the CRT will probably lose the fight, but it is not clear that the final victor will be any of the technologies we have discussed. If it is they will be very much advanced versions of what is available today. ●

WOOD FOR CHIPS ... WOOD FOR CHIPS ... WOOD FOR CHIPS ... WOOD FOR CHIPS ... WOOD FOR CHIPS ... WOOD ... WOOD FOR C

WHEN GEOFF DOES A KIT HE DOES IT PROPERLY

Geoff's policy is to do a few kits and do them well. Rather than bundle up bits and pieces for everything under the sun, Geoff takes a lot of trouble to get all the RIGHT parts for just a few projects. As a result you can be assured that there are no dubious substitutions and that all parts are prime spec.

Also the projects are checked out before the kit is even considered. Both of this month's projects had mistakes in the original articles - in both cases the PCB layout was incorrect - and Geoff was the one who spotted the errors.

AEM4600 DUAL SPEED MODEM

Geoff can't put this kit together fast enough. The queue started to form the moment the magazine came out.

Features both 300/300 baud full duplex and 1200/75 baud half duplex operation so it's ideal for Viatel. All functions are selected with quality C&K toggle switches with four LEDs to indicate correct functioning. Interfacing is standard RS232 using a minimum of signal lines for "universal" interfacing.

Geoff's kit comes complete with punched front panel (looks like a bought one!) and is just **$159.00**

ETI 169 LOW DISTORTION OSCILLATOR

If you're checking out Hi Fi systems then an audio oscillator is a must. The trouble is that the average el-cheapo probably has a higher level of distortion than a $10 transistor radio. So with this kit there can be NO compromises. The distortion just has to be better than 0.001%. Covers the frequency range to 100kHz. Geoff has checked the whole thing through with Ian Thomas (including pointing out the track error on the pcb).

Kit again includes a posh front panel and the top quality AB pot (available separately at **$9.00**).

Complete kit **$179.00**

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Selection Guide

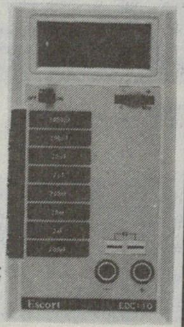
	EDM-1105	EDM-1116	EDM-1125	EDM-1135	EDM-1346
Basic Feathers					
Number of Digits Display	3½ LCD	3½ LCD	3½ LCD	3½ LCD	4½ LCD
Continuity & Beeper	–	–	•	•	•
True RMS	–	–	–	–	•
hFe & Capacitance	–	•	–	–	–
Data Hold	–	–	–	–	•
Peak Hold AC/DC	–	–	–	•	–
Basic Accuracy Percent of Reading	0.8	0.5	0.25	0.1	0.05
DC Volts					
Maximum Resolution Microvolts	100	100	100	100	10
Lowest Range Millivolts	200	200	200	200	200
Maximum Voltage	1000	1000	1000	1000	1000
AC Volts					
Maximum Resolution Microvolts	100	100	100	100	10
Maximum Voltage	750	750	750	750	750
Frequency	500Hz	500Hz	1KHz	5KHz	5KHz
AC & DC Amps					
Resolution	1uA	1uA	1uA	1uA	100nA
Maximum Current	10A	10A	10A	10A	10A
Ohms					
Maximum Resolution Milliohms	100	100	100	100	10
Maximum Resistance Megohms	20	20	20	20	20

•Standard – Not Applicable

Display 3½ digit LCD reads 1999 maximum. 4½ digit LCD reads 19999 maximum. (EDM-1345 only)
Polarity Automatic, (–) negative polarity indication.
Zero Adjustment Automatic
Overrange Indication Highest digit of (1) or (-1) is displayed.
Low Battery Indication The (Lo Bat) is displayed when the battery voltage drops below the operating voltage.
Measurement Rate 2.5 measurements per second, nominal.
Operating Temperature 0°C to + 35°C 0-80% RH, +35°C to + 50°C 0-70% RH.
Storage Temperature -20°C to +65°C 0-90% RH with battery removed.
Accuracy Accuracy specifications at 23±5°C, less than 75% RH.
Power Single, standard 9-volt battery, NEDA1604, JIS006P, IEC6F22.
Dimensions 6.89 inches (17.5cm) long x 3.58 inches (9.1cm) wide x 1.4 inches (3.6cm) high.
Accessories Test leads (Pair), Spare fuse, Battery, Operator's manual.

Model	Features	Ex Tax	Inc Tax
EDM1105	Low Cost 3½ digits	$ 75.00	$ 86.25
EDM1116	Capacitance Tester	$100.00	$115.00
EDM1125	Continuity Beeper	$108.00	$125.30
EDM1135	Peak Hold	$140.00	$162.40
EDM1346	True RMS	$225.00	$258.75

EDC-110 Capacitance Meter



- **3½ LCD display**
- **0.5% basic accuracy**
- **Fuse protection**
- **Measures lpF!**

Capacitance
200 pF - 2,000 uF, 8 ranges:
0.1 pF max resolution
Accuracy
200 pF - 20 uF (+0.5% rdg)
200 uF (1.0% rdg)
2000 uF (2.0% rdg)
Accessories included: Test clips, spare fuse, Owner's Manual, battery.

DLC 400 LC Meter

Inductance and Capacitance Measurement
- **3½ digit LCD display**
- **Input protected against charged capacitors**

Inductance:
2 mH - 2 H, 4 ranges;
1 uH max resolution, 2%
1 kHz test frequency

Capacitance:
2 nF - 200 uF, 6 ranges;
1 pF max resolution, 1%
1 kHz test frequency 2 nF - 2 uF,
100 Hz test frequency 20 uF - 200 uF
Accessories included: Test clips, spare fuse, Instruction Manual.

8.30 to 5 Monday to Friday. 8.30 to 12 Sat.
Mail Orders add $3.00 to cover postal charges.
Next day delivery in Sydney add $5.00.

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TECHNICS PORTABLE PLAYER

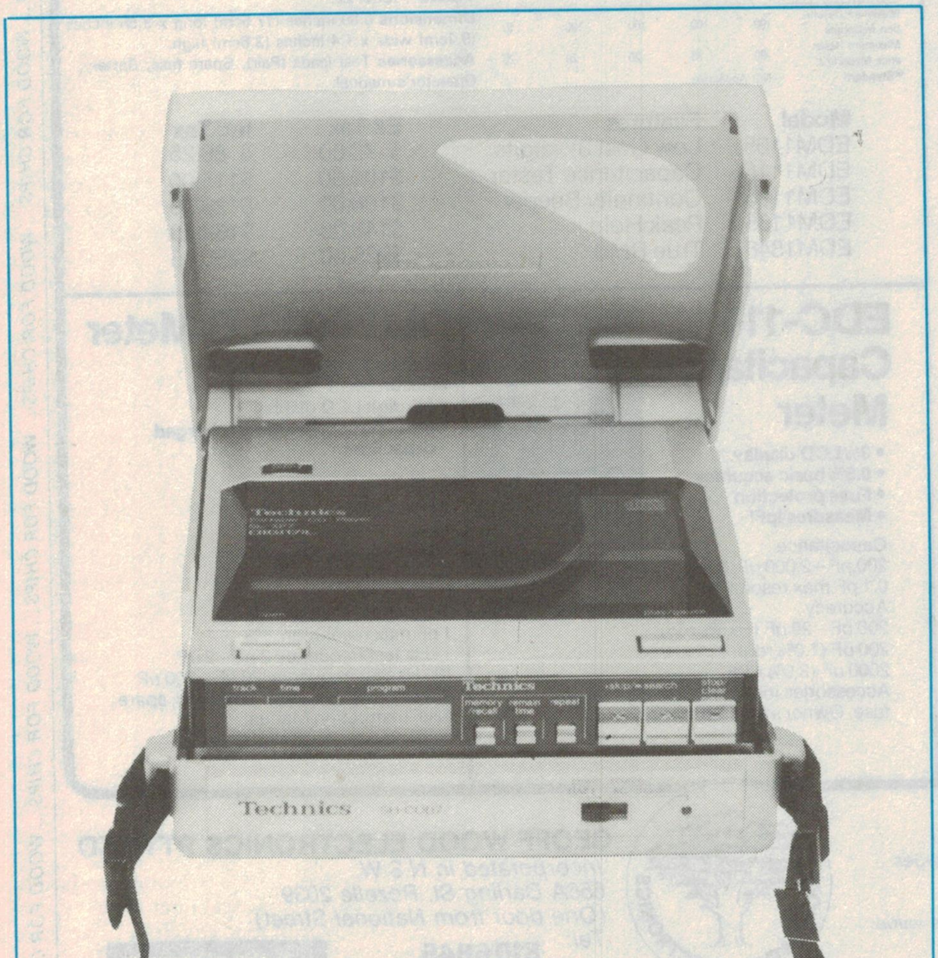
— the SL-XP7 CD player

Like some small, sleek temptress this CD player should have most hi-fi enthusiasts ogling from near or far. But it's what's behind the taught, trim figure that counts to make it terrific.

Louis Challis

THE SL-XP7 PORTABLE CD player, the smallest CD player on the market, was released in December last year in Australia and is an outstanding example of consumer product engineering. Technics has devoted its best efforts to providing a miniature CD player which you are likely to find just as exciting as I have.

There are, of course, many general similarities between the SL-XP7 portable CD player and the Sony D-50 which was released late 1984 (see ETI March 1985).



But on some points the players diverge considerably.

Features

The 'basic' player is an extremely neat unit featuring a silver plastic envelope, incorporating sections of black trim to provide a highlighting feature (in sharp contrast to the Sony D-50 which is virtually all black with very small areas of silver trim).

The casing is neatly moulded from plastic to keep the weight down. The dimensions are particularly small which you notice as soon as you pick up the unit and hold it in the palm of your hand. The top of the cabinet (if one can call it that) incorporates a black plastic insert with overlying clear plastic cover through which you can see portions of a disc if one has already been loaded into the player.

At the left hand corner of the front panel is an elongated and raised pushbutton catch, which when pressed, releases the main cover. This pops up and must then be

TECHNICS SL-XP7 PORTABLE COMPACT DISC PLAYER

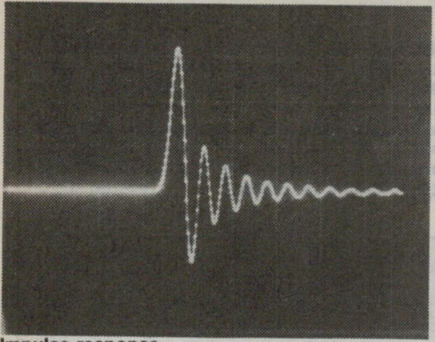
Dimensions:	*126 mm x 126 mm x 31.9 mm (high)*
Weight:	*520 g*
Manufacturer:	*Matsushita, Osaka, Japan*
RRP:	*$529*

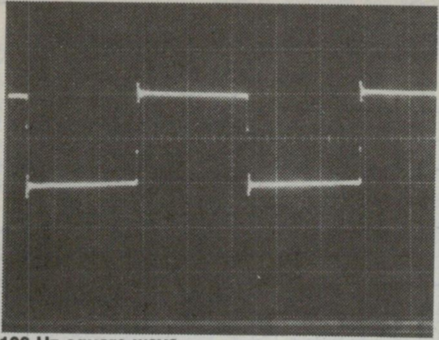
SH-CDB7 Carrying Case and Battery Pack

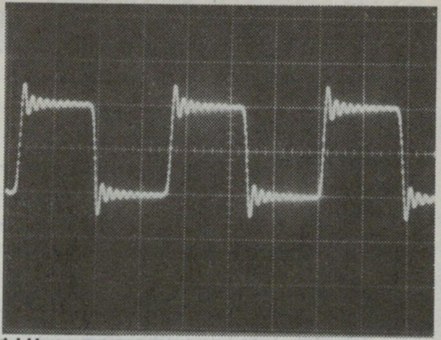
Dimensions:	*137 mm (wide) x 150 mm (deep) x 58 mm (high)*
Weight:	*680 g*
RRP:	*$169*

ac Adaptor — SH-CDA3U

Dimensions:	*80 mm (long) x 55 mm (high x 48 mm (wide)*
Weight:	*490 g*
(provided with SL-XP7)	


Impulse response


100 Hz square wave


1 kHz square wave

manually raised to provide normal access to the disc well. This feature is very similar to that used by Sony in its D-50 CD player.

At the right hand corner of the front panel is a very accessible, dual function PLAY/PAUSE switch. On the left hand side of the casing is the power ON/OFF switch, on the right hand side a VOLUME control and a HIGH PASS filter. Adjacent to these controls is a 3.5 mm diameter tip ring and sleeve socket to accept external headphones fitted with miniature jack.

On the front of the panel extending from the left hand side to almost the centre is a large liquid crystal display. This provides data on the TRACK number, the TIME in minutes and seconds and a PROGRAM indicator which displays 15 numbers. Adjacent to the fifteenth number is an arrow indicating, when relevant, that there are more than 15 tracks available on the disc.

The primary controls on the right hand side of the front panel include a SKIP button which allows you to skip backwards one track at a time, a SEARCH button which allows you to move forward one track at a time, and a STOP/CLEAR button which allows you to clear your control functions if the memory or other functions have been activated.

The minor controls with much smaller and almost miniscule pushbuttons, include a MEMORY/RECALL button, and a REMAINING TIME button, which switches the time display from played time on the track to total remaining time on the disc in minutes and seconds. A REPEAT button allows the disc to recycle from start right through to the end.

The simplest way in which this player may be used is with its separate ac transformer rectifier adaptor unit which plugs into the back panel by means of a simple polarised 3-pin connector plug. Immediately adjacent to this is a miniature tip ring and sleeve socket which provides the line output facility. By plugging in a separate tip ring and sleeve lead, which is terminated at the other end with two RCA sockets, you can directly amplify this player's output through your existing hi-fidelity system or, if you prefer, by means of headphones using the headphone socket on the right hand side of the player.

As nice as the adaptor may be, I would recommend the slightly more expensive approach of purchasing the Technics SC-CDB7 battery pack. This has many advantages over the corresponding Sony EBP-9LC battery case which was designed to take rechargeable (and replaceable cells) in its CD 'walkman' case; the Technics player has come up with a far neater twist, incorporating a complete layer of batteries in the bottom of the case, immediately below the player. This results in the battery case dimensions being almost imperceptibly larger than those of the player; the player sits about 20 mm higher than it did in the bare state.

The battery pack/carrying case is provided with a BATTERY power switch or ac/CHARGE switch on the front and uses the same ac adaptor for charging the batteries or for powering it directly off mains. The player is retained in the battery pack by means of a spring loaded screw located at the top centre of the back panel so that it doesn't fall out; it is protected by a supplementary lid and cover. This cover uses two spring loaded catches on both sides near the front of the case. The battery pack cover features a striped plastic insert which offers a little more protection and a trace of graphic relief from what would otherwise be a blatantly stark silver finish.

When the lid of the basic player is raised, you catch sight of the laser source and detector assembly mounted on a slide mechanism, which bears some resemblance to the system used in the Sony D-50, but the method of support and its design are different. This is only clearly seen when the player and the mechanism are removed from the case.

Like Sony, and for the same reasons, Technics has gone to considerable trouble to design specialised large scale integrated circuitry for this particular player.

Objective testing

The objective testing of the SL-XP7 was relatively straightforward, and certainly simplified by the wider range of test material now available for CD players.

The frequency response of the player is within ±0.4 dB from 20 Hz to 20 kHz and within ±0.6 dB from 5 Hz to 22.05 kHz. That sort of linearity is particularly good and ought to convince you that although the unit is remarkably small, it is most certainly *not a toy*.

The digital-to-analogue conversion linearity is almost ruler straight from 0 dB to −60 dB where it starts to display modest curvature. This curvature increases rapidly with decreasing dynamic range so that by the time the signal level is down to −90 dB, you have a substantial −60 dB non-linearity (−84.1 dB in the left channel and −84.5 dB in the right channel). These figures are reasonable but not outstanding.

The channel separation is excellent at 100 Hz (−81.6 dB), reasonable at 1 kHz (−63.6 dB), decidedly poor at 10 kHz (−44.6 dB), and extremely poor at 20 kHz (−39.3 dB). The reasons for this sloping channel separation are not clear and exemplify the lowest channel separation figures which we have so far seen in CD players.

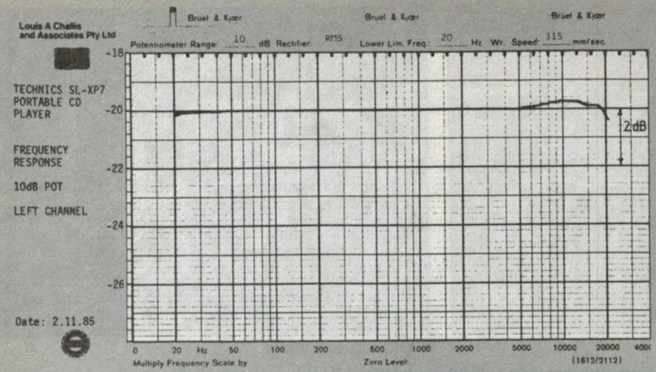
The distortion characteristics, however, are reasonably good with a total thd which is 0.0066% at 0 VU (higher than the manufacturer claims). But the distortion figures do not become significant until signal levels drop to −50 dB at which point the distortion level has climbed to 0.64%. At −80 dB the distortion has climbed to 9.22%, at −90 dB the figure is 25.4%. The distortion at 100 Hz is higher and at 6.3 kHz much higher.

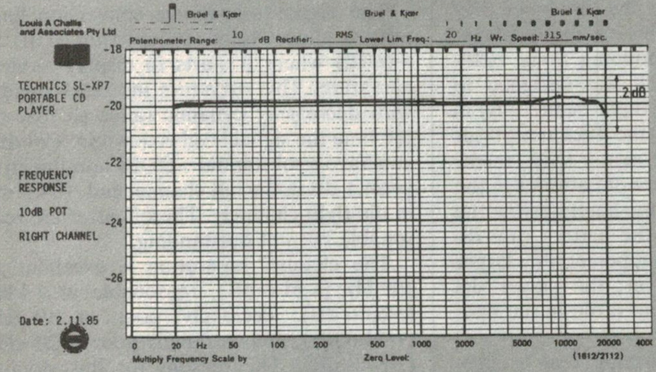
The signal-to-noise ratio figures are quite good being 94 dBA (without emphasis) and 95.5 dBA with emphasis. The frequency accuracy of the player is −4 Hz for a 19.999 kHz test signal.

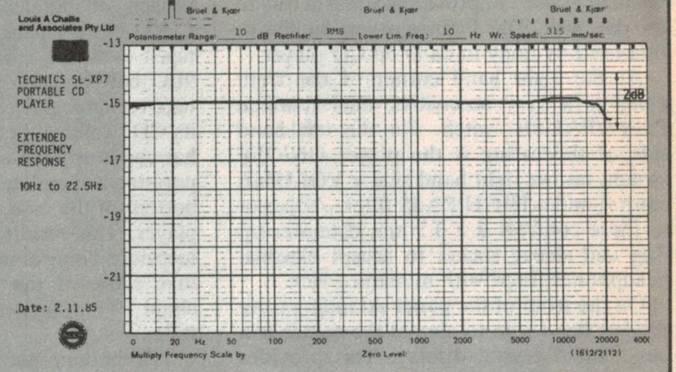
In the 'dirty disc test' the interruption in the information layer test produced no adverse results but the player could not cope with any of the black dots from 300 micrometre to 800 micrometre diameter. The player would not track a 2° skew disc but played our eccentric test discs.

One important characteristic which we evaluated is the ability of the CD player to withstand vertical and horizontal vibration. This is particularly important for joggers, as well as for use in vehicles. The unit will withstand vertical acceleration levels of 0.2 g at 5 Hz quite happily but is incapable of coping with lateral acceleratioon levels in excess of 0.05 g at frequencies in the range 5 Hz to 25 Hz.

This limited lateral vibration resistance does provide a practical limit to the type of vehicle or type of road condition in which or on which the player may be used. The overall objective performance characteristics of ▶







MEASURED PERFORMANCE OF TECHNICS PORTABLE CD PLAYER
MODEL NO. SL-XP7
SERIAL NO. NH 5810A048

1. FREQUENCY RESPONSE

20 Hz to 20 kHz ± 0.4 dB
5 Hz to 22.05 kHz ± 0.6 dB

2. LINEARITY
@ 1kHz

TRACK	NOMINAL LEVEL	L. OUTPUT	R. OUTPUT
1	0dB	0.0	0.0
22	-1.0	-1.0	-1.0
23	-3.0	-3.0	-3.0
24	-6.0	-6.0	-6.0
25	-10.0	-10.0	-10.9
26	-20.0	-20.0	-20.0
27	-30.0	-30.0	-30.0
28	-40.0	-40.0	-40.0
29	-50.0	-49.9	-50.0
30	-60.0	-59.7	-59.6
31	-70.0	69.0	-69.0
32	-80.0	-79.6	-79.6
33	-90.0	84.1	-84.5

3. CHANNEL SEPARATION

FREQUENCY	RIGHT INTO LEFT dB	LEFT INTO RIGHT dB
100Hz	-83.2	-81.6
1kHz	-63.6	-63.7
10kHz	-44.7	-44.6
20kHz	-39.3	-39.3

4. DISTORTION (@ 1kHz)

Level	2nd	3rd	4th	5th	THD%
0	-83.8	-97.9	-	-	0.0066
-1.0	-84.7	-97.4	-	-	0.006
-3.0	-87.6	-	-	-	0.0042
-6.0	-89.5	-	-	91.7	0.0042
-10	-	-84	-	-92.4	0.0067
-20	-73.7	-	-	-81.0	0.022
-30	-	-70.4	-	-75.3	0.035
-40	-	-68.6	-	-66.6	0.06
-50	-	-45.1	-	-50.1	0.64
-60	-	-38.6	-	-45.8	1.28
-70	-	-31.9	-	-39.7	2.74
-80	-	-21.8	-30.1	-30.4	9.22
-90	-16.0	-	-20.0	-15.3	25.4

Using Disk DENON 38C39-7174 (@ 100 Hz)

Level	2nd	3rd	4th	5th	THD%
0	-88.7	-95.2	-111.6	-98.7	0.0042
-20	-90.3	-78.7	-	-84.2	0.013
-40	-73.2	-69.3	-	-66.9	0.061
-60	-49.8	-38.7	-54.4	-43.0	0.80
@ 6.3 kHz					
0	-79.3	-86.3	-	-	0.012

5. EMPHASIS

Track	Frequency	Recorded Level	Output Level (L)	Output Level (R)
39	1 kHz	-0.37 dB	-0.4	-0.3
40	5 kHz	-4.53 dB	-4.1	-4.2
41	16 kHz	-9.04 dB	-8.9	-9.2

6. SIGNAL TO NOISE RATIO

Without Emphasis	83.2 (Lin)	94.0 dB(A)
With Emphasis	88.8 (Lin)	95.5 dB(A)

7. FREQUENCY ACCURACY

-4 Hz for 19.999 kHz test signal

8. SQUARE WAVE RESPONSE

100Hz Square wave
1kHz Square wave
See attached photos

9. IMPULSE TEST

DIRTY RECORD TEST

Interruption in Information Layer
400 micrometer ; Passed
500 micrometer ; Passed
600 micrometer ; Passed
700 micrometer ; Passed
800 micrometer ; Passed
900 micrometer ; Passed

Black Dot at Read out Side
300 micrometer ; Failed
500 micrometer ; Failed
600 micrometer ; Failed
800 micrometer ; Failed

SKEW TRACKING TEST
Test Disc Skew angle 2° skew failed.

VIBRATION OR DISPLACEMENT TEST

Vertical Acceleration level 0.2g failed
Lateral Acceleration level 0.05g failed

OUTPUT IMPEDANCE

Head Phone Amplifier output impedance 60 ohms

the Technics SL-XP7 were quite good and most certainly better than one would expect from a CD player so tiny.

Subjective testing

The subjective testing of the player was a treat, especially as I had just received some new and exciting discs to review. The first of these was Mozart's "Eine Kleine Nachtmusik" with the Academy of St Martin-in-the-Fields' Chamber Ensemble (Philips 412 269-2). This contains one of the most exquisite renditions of Mozart's best known piece of music. The SL-XP7 provided an almost superb evaluation system. I compared it with a series of other CD players which sell at five times the price, and I could not readily detect any significant subjective difference between this unit and the other 'reference' CD players.

The next discs that I listened to were a new release of Handel's "Messiah" with Robert Shaw and the Atlanta Symphony Orchestra & Chamber Chorus (Telarc CD 80093-2). This set of two discs is undoubtedly one of the finest renditions of the "Messiah" to be released, a real must if you collect Handel. I took the SL-XP7 with me in the car and I was able to hear the whole of the "Messiah" as I drove on one of my rare long car journeys. The player performed relatively well on the good sections of road but experienced considerable tracking problems on the rougher sections of road, even when mounted carefully on a pillow on the front seat.

I found that the alignment of the player, with respect to the direction of travel did make a significant difference in trackability, as did the speed at which I travelled.

In a good car on a good road, the SL-XP7 copes adequately with the incipient vibration. In a poorly-sprung car or on a bad road, the SL-XP7 does not cope at all well.

Although the SL-XP7 is a portable player, it has not been specifically designed for automotive use, nevertheless it performs adequately under appropriate conditions.

The SL-XP7, when mounted in the SH-CDB7 (the carrying case), offers a neater and far more practically sized package than the Sony D-50. As a consequence, it will appeal to a wide circle of intending users who are seeking a 'go anywhere' solution for their personal musical entertainment. This player is only about twice the size of most small compact cassette players, but it offers much more than twice the listening pleasure.

The Technics SL-XP7 is a delightful example of high technology in consumer engineering. It has lots of panache, is loaded with innovative technology and will help to create a new market for CD discs which most audiophiles have considered restricted to the home domain. ●

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ANOTHER STEP FORWARD

— B&W DM330 loudspeakers

Louis Challis

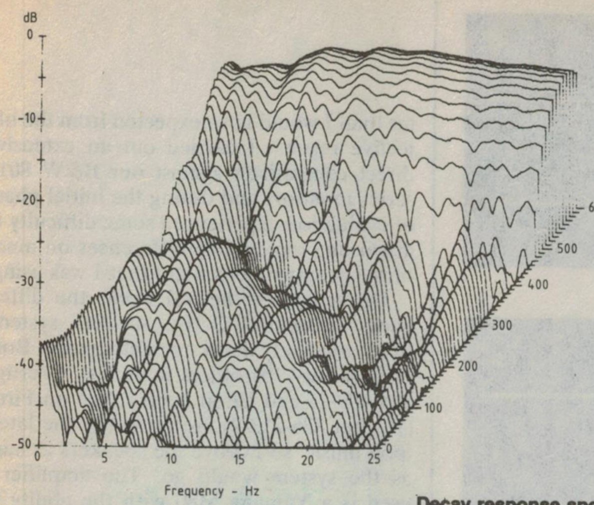
Past the hurdles and over the stumps, B&W is now well established as a speaker manufacturer we expect a good deal from. And with just the odd quirk that seems to be what we've got.

B&W LOUDSPEAKERS LTD started as Bowers & Wilkins in 1966. It produced a number of 'interesting' but not particularly exciting speakers in the first few years of operation; it was not until 1969 that it produced a truly outstanding speaker. The DM70 was a true landmark in speaker development and when I reviewed it (ETI November 1973) I was pretty impressed by its smooth performance. In the intervening period, B&W has produced a number of advanced speakers with the 801 and 801F in particular now regarded as examples of the most outstanding speakers commercially available.

In 1980 B&W, like many of its competitors, was hit rather hard by the world trade recession. Instead of taking a 'defensive position', as it may well have done, B&W elected to go on the offensive through the development of a completely new range of 'cost effective' speaker drivers. This ambitious approach led to the development of the DM110 and DM220 speaker series, which I reviewed in ETI, September 1981. As good as the DM110 was (or is), its most serious limitation was its inability to pro-

B&W DM330 LOUDSPEAKERS

Dimensions:	*965 mm (high) x 290 mm (wide) x 338 mm (deep)*
Weight:	*16.5 kg*
Manufacturer:	*B&W Loudspeakers Ltd, England*
RRP:	*$899*



Decay response spectra.

MEASURED PERFORMANCE OF: B&W DM330 Loudspeakers

SERIAL NO: 14749

FREQUENCY RESPONSE: 50 Hz - 22 kHz

CROSSOVER FREQUENCIES: 2.8 kHz

SENSITIVITY: (for 90 dB average at 2m) 8.4 Watts (nominally into 8 Ohms)

HARMONIC DISTORTION: (for 90 and 96 dB at 1m)

	100Hz (90 dB)	100Hz (96 dB)	1kHz (96 dB)	6.3kHz (90 dB)	
2nd	-31.1	-21.6	-61.8	-53.6	dB
3rd	-49.3	-40.5	-41.6	-27.5	dB
4th	-	-51.9	-	-63.6	dB
5th	-65.4	-64.1	-65.5	-	dB
THD	2.8	8.4	0.83	4.2	%

INPUT IMPEDANCE ONE TEST:

	100Hz/7kHz 4:1	
100Hz	8.8	ohms
1kHz	18.4	ohms
6.3kHz	9.2	ohms
Minimum at 2.8 kHz	6.9	ohms

duce good low frequency performance. My previous criticism, and I presume that of many other reviewers and purchasers, induced B&W to try a little harder to produce a speaker with the same basic attributes but with a larger enclosure which is capable of producing the type of low frequency performance that most purchasers are really seeking.

The DM330 is an excellent embodiment of the fundamental DM110 design philosophy but without the limitations that the DM110's small speaker cabinet imposes. With a volume of approximately 90 litres and an acoustical suspension based on the principles developed by AR in the States, the fully sealed enclosure makes it possible to achieve a healthy and very practical bottom-end frequency response. This response extends down to 55 Hz, the region that I would specify as the minimum frequency response most listeners would want for either classical, pop rock or jazz music.

Design

The design is not visually exciting and was undoubtedly never intended to be. It features a tall narrow fronted cabinet with removable black front trim overlying a speaker configuration that the manufacturer describes as a three-way system in the standard brochure.

Behind the removable black cloth covered speaker grille are two 200 mm diameter frequency drivers and a 25 mm diameter soft dome tweeter. Each of these drivers features a neatly designed diecast basket frame with soft surround speaker diaphragm and ferrite magnet assembly. This combination achieves reasonable performance at a modest cost. The external face of the speaker frame is truncated on the upper and lower edges of the surrounds to facilitate close spacing of the drivers on the front of the cabinet.

The low frequency drivers have been visually dressed by the provision of an attractive blue ring, a feature that B&W has incorporated in its speakers since the development of the DM110 series. It is possible that the colour may have some significance, as some of the drivers have a red ring instead of the blue, but I have yet to find the answer.

The tweeter is located close to the top of the cabinet to provide the best possible dispersion, while the two low frequency drivers are located sufficiently high above the floor to achieve an enhanced low frequency radiation. The cabinet is constructed with 18 mm thick plastic veneered particleboard with a black finish (although other finishes are available). In this a central particleboard stiffening frame has been integrated to limit cabinet resonance, which would otherwise be a problem. This approach is novel and practical and appears to work very well. Its use facilitates the placement of open cellular foam between the stiffening frame to provide controlled cabinet resonance, without materially increasing the weight (nor the cost) of the system.

The speaker crossover network is screwed to the back panel and a close examination of the components and the configuration suggested it is not a three-way crossover system. This conclusion is also confirmed by our laboratory measurements which reveal only one notch in the near-field driver measurements.

The terminal recess on the back panel incorporates a fuse holder for the protection system. This may provide limited protection against catastrophic failure, but not effectively against high frequency transients.

Objective testing

The objective testing of the speaker proved to be particularly interesting because of my interest in determining whether the DM330 is a two-way system, or a three-way system.

The on-axis frequency response in our anechoic room confirmed that the speaker really does produce an extremely smooth response with the lower frequency peformance, much better than I would have expected; the high frequency end of its output is truly outstanding. The off-axis response (at 30°) showed a minimal droop above 15 kHz, but even at 20 kHz the response had only dropped by a little more than 10 dB. This performance is excellent, particularly when the price of the speaker system is considered.

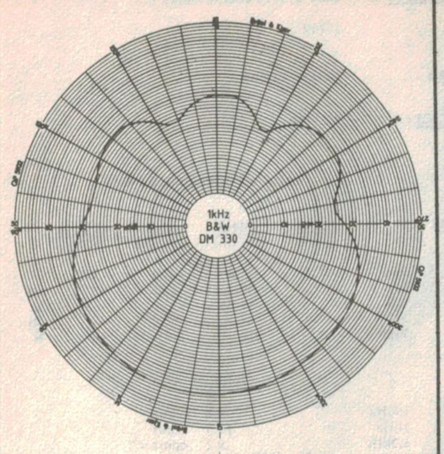
The close proximity measurements, performed immediately in front of the drivers, revealed no trace of the system providing a three-way response nor did our measurements. The only crossover frequency found was at approximately 2.5 kHz. The reference to a three-way system in the literature is misplaced, and if it were not for the otherwise excellent performance of the speaker, I would probably pick a fight on this issue.

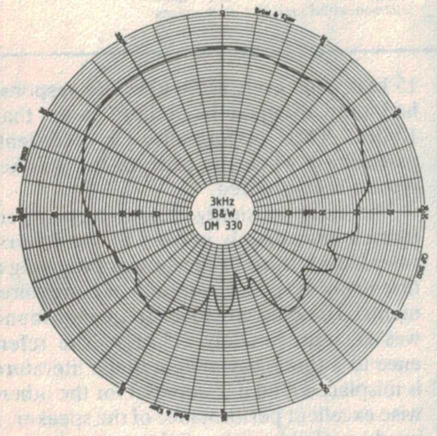
The polar plots revealed a truly outstanding high frequency performance with the 6.3 kHz and 10 kHz plots providing some of the best polar performances I have seen in recent years. The addition of foam around the tweeter probably materially enhances the performance while the removal of the front speaker protection also results in an improvement of off-axis frequency performance. However I doubt whether most users would be willing to risk their speaker diaphragms by leaving them unprotected in such a way.

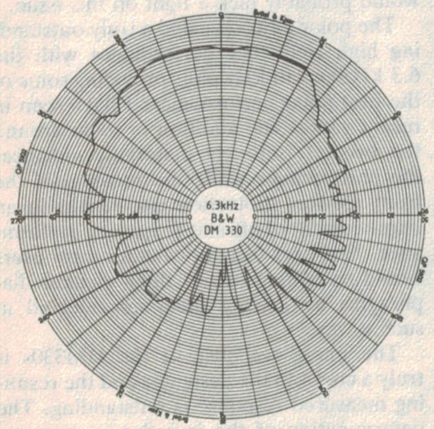
The phase response of the DM330s is truly a credit to the designers and the resulting measured response is outstanding. The determination of the impedance curve revealed a very smooth response with a general impedance threshold of precisely 8 ohms dropping down to approximately 7 ohms in the region of the crossover at 2.8 kHz. As a result of the general uniformity of the curve, these speakers would be well suited to parelleling with other speakers when more than one room is to be served by a single amplifier.

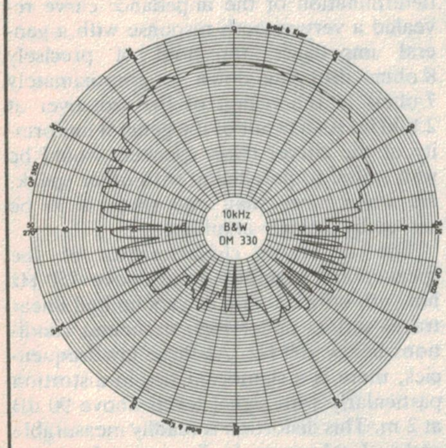
The distortion characteristics of the speaker are generally good above 150 Hz but with only 200 mm drivers limited linear travel suffers under high excursion conditions below 100 Hz. At these low frequencies, there is a significant rise in distortion particularly with signal levels above 90 dB at 2 m. This distortion is readily measurable and as I subsequently discovered for some ▶

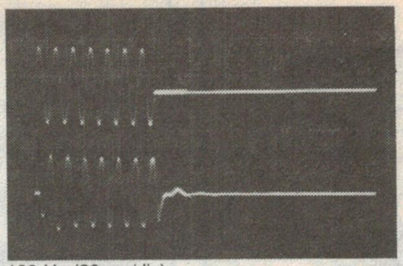
Polar response plots.



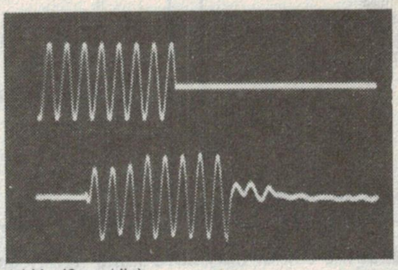




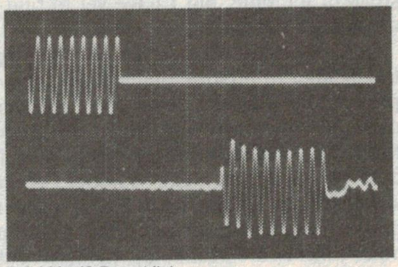




100 Hz (20 ms/div)



1 kHz (2 ms/div)



6.3 kHz (0.5 ms/div)

Tone burst response of B&W DM330 loudspeakers for 90 dB steady state SPL at 2 m on axis. Upper trace is electrical input. Lower trace is loudspeaker output.

programme content, quite audible.

The tone burst testing revealed a trace of anomalous behaviour in the 1 kHz region, although at the other test frequencies showed very little.

Since its development, I have found a correlation between the measurements provided by our decay response spectra evaluations and the subsequent subjective impressions. In this case, the decay response spectra reveal a particularly smooth performance with a superlative high frequency response, virtually free of any colouration until the 2-6 kHz region where some significant resonant ridges are clearly evident in the 100 microsecond to 5 millisecond region. These are clearly evident at signal levels of the order of 10 dB below peak level and very evident at around 25 dB below peak level. They appear to be primarily associated with a low level speaker cone resonance and are subsequently picked up by a cabinet resonance. Even so, the overall decay response spectra are by and large excellent, again particularly when the price of the speaker is considered.

Subjective testing

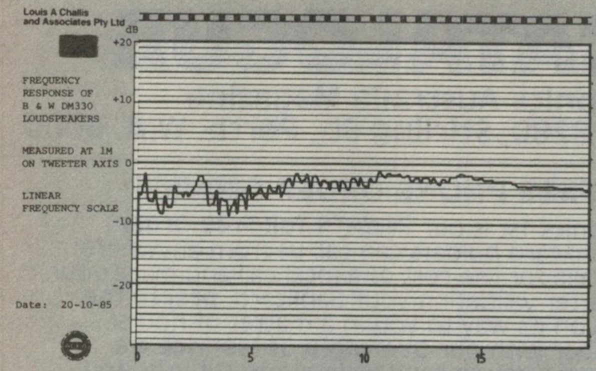
The subjective assessment of the DM330s proved to be quite delightful, and even better than I would have expected from the objective results. I carried out an extensive direct comparison against our B&W 801F series monitors and during the initial phase of evaluation experienced some difficulty in discerning the audible differences on much of the programme content that I was using.

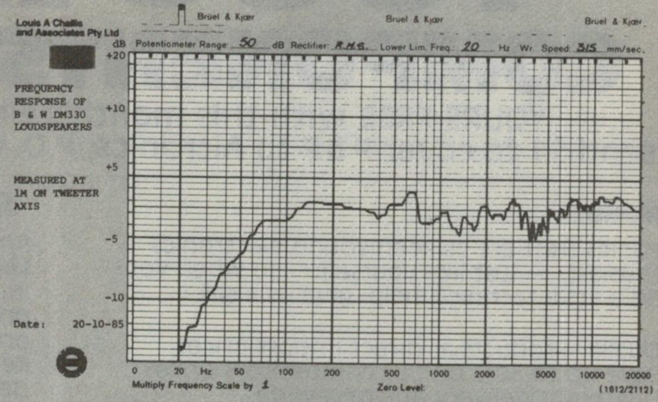
On general orchestral work, the differences between the two speaker systems were relatively hard to distinguish. Both Dire Straits' "Brothers in Arms" (Vertigo 824 499-2) and Elton John's "Ice on Fire" (Rocket 826-213-2) are typical of the latest 'pop music' so I drove the speakers as hard as the system would go. The amplifier I used is a Yamaha M80 with the ability to produce peak outputs of over 400 watts per channel. Although the systems do not incorporate an electronic protection system, the B&W DM330s had no problems in producing peak levels of over 105 dB at 2 m. Rather surprisingly these signals were produced with very little signs of audible distress and with a signal that was still clean enough to satisfy most pop or rock devotees. The signal did exhibit signs of frequency doubling with components below 80 Hz.

With a more selective choice of music, such as Barbra Streisand and Barry Gibb singing on "Guilty" (CBS half speed mastered CBSH 86122) and similarly with Kenny Rogers on "Kenny Rogers' Greatest Hits" (Mobile Fidelity MFSL 1-049), I was easily able to hear differences between the DM330s and B&W 801Fs. This shows up as a pronounced increase in 'presence' in the 2-4 kHz region but was not really disturbing and may possibly even be preferred by many listeners. There was also a discernible increase in sibilance to boot. Not surprisingly my younger son was pointed in his praise of the DM330s.

Listening to a Nakamichi demonstration tape (Metalloy Sound S013) featuring Brahms' Symphony No 4, 3rd Movement, played on a Nakamichi Dragon and other percussive material on the same tape, it was virtually impossible to tell whether you were listening to the B&W monitors or the DM330s. This was generally the case on a wide range of other classical music to which I listened sourced from compact discs or conventional microgroove recorded material.

The DM330s are an excellent speaker system with many attributes which make them suitable for classical, rock and pop. At a current recommended retail price of $899, they constitute really excellent value. Even though I am not happy with the manufacturer's choice of description as a three-way system, I must acknowledge, nonetheless, that I am impressed by them. They almost provide 'monitor-type performance' at a fraction of the price of the real McCoy. ●


Louis A Challis and Associates Pty Ltd
FREQUENCY RESPONSE OF B & W DM330 LOUDSPEAKERS
MEASURED AT 1M ON TWEETER AXIS
LINEAR FREQUENCY SCALE
Date: 20-10-85


Louis A Challis and Associates Pty Ltd
Brüel & Kjær
FREQUENCY RESPONSE OF B & W DM330 LOUDSPEAKERS
MEASURED AT 1M ON TWEETER AXIS
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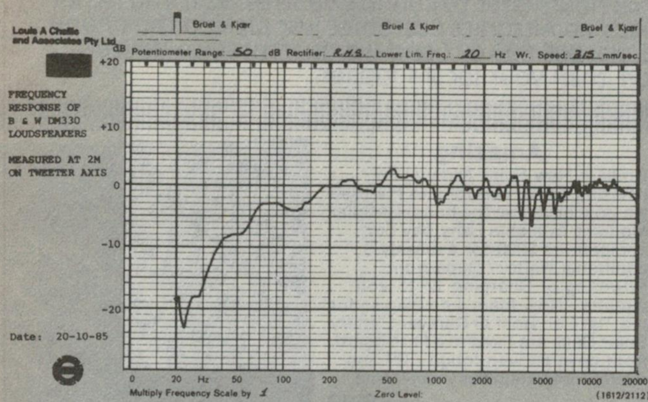
Louis A Challis and Associates Pty Ltd
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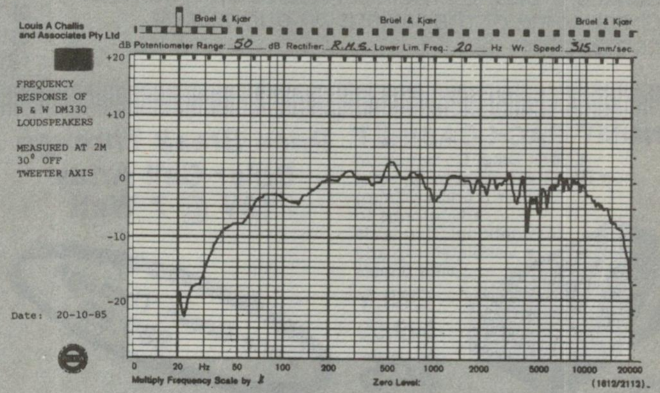
MEASURED AT 2M ON TWEETER AXIS
Date: 20-10-85


Louis A Challis and Associates Pty Ltd
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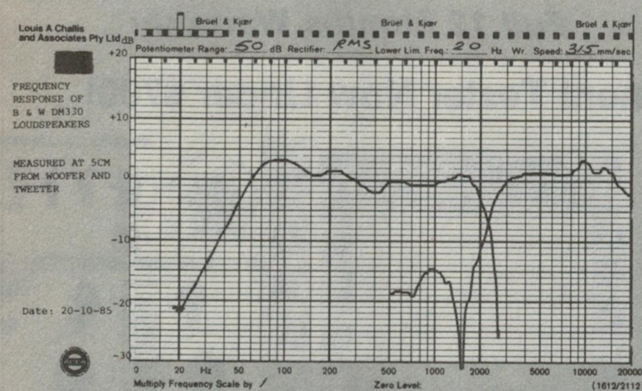
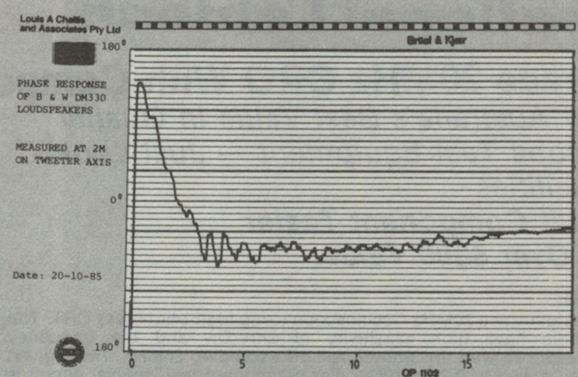
FREQUENCY RESPONSE OF B & W DM330 LOUDSPEAKERS
MEASURED AT 2M 30° OFF TWEETER AXIS
Date: 20-10-85


Louis A Challis and Associates Pty Ltd
Brüel & Kjær
FREQUENCY RESPONSE OF B & W DM330 LOUDSPEAKERS
MEASURED AT 5CM FROM WOOFER AND TWEETER
Date: 20-10-85


Louis A Challis and Associates Pty Ltd
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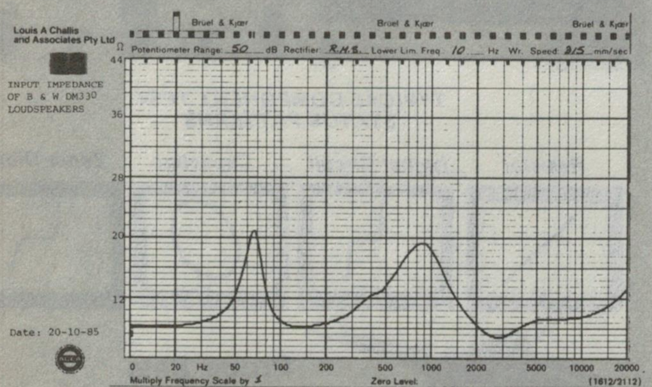
PHASE RESPONSE OF B & W DM330 LOUDSPEAKERS
MEASURED AT 2M ON TWEETER AXIS
Date: 20-10-85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INPUT IMPEDANCE OF B & W DM330 LOUDSPEAKERS
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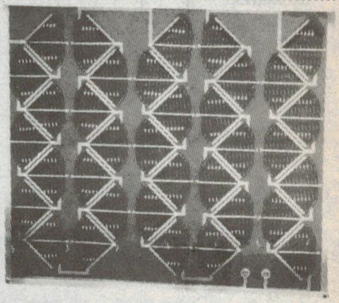

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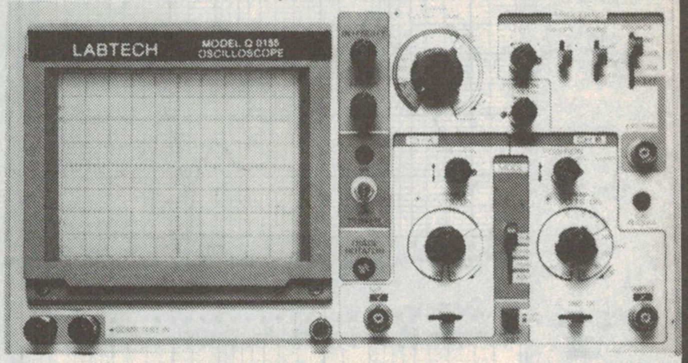

DESCRIPTON:
This model is a dual-trace 20MHz Oscilloscope using high brightness CRT. The vertical amplifiers have high sensitivity of 5mV/Div and the frequency characteristic response with the smooth roll off exceeding 20MHz. The highest triggering sweep speed is 0.2 usec/Div. For component test, special circuit is designed, with which a single component or components in or out of actual circuit board can be easily tested, requiring no power to drive the circuit. The display shows fault of components, size of a component value, characteristics of component, and half-dead components under dynamic test.

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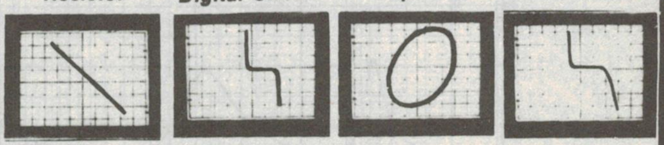
TYPICAL COMPONENT TEST STATUS PATTERNS



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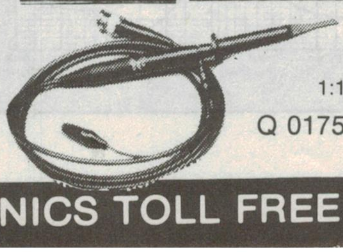

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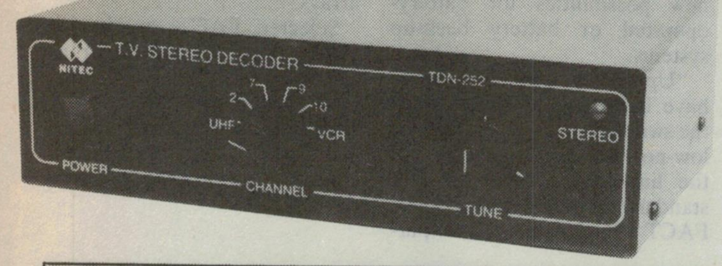
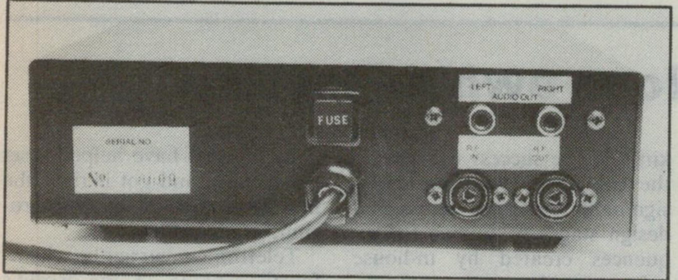
Stand alone stereo TV decoder





Melbourne company, Nitec, is offering an Australian designed and manufactured stereo TV decoder which has caught our interest, and apparently that of the Victorian government which awarded Nitec an innovation accolade.

The Nitec TDN-25-2 apparently, and rather neatly, turns your existing mono TV stereo, with only the assistance of your hi-fi.

The TDN-25-2 is a small black box which links into the aerial and the aerial socket on the TV with leads extending from the box to connect up to your amplifier and speakers.

Working details as we know them are that the TDN-25-2 with its own receiver circuitry, IF and demodulator, detects and demodulates the signal, and outputs to the amplifier. The intercarrier FM demodulator in line with the dual carrier system operates on input frequencies of 36.875 MHz picture carrier and 31.375 MHz and 31.133 MHz sound carriers. Input range is 60 dB. Other specs are of output of 250 mV at 50 kHz deviation, less than 200 ohm impedance and audio frequency response of 29-15 kHz ±3 dB.

The device automatically switches between mono and stereo decoding depending on the signal. An indicator light on the front illuminates on a stereo transmission. Also on the front are two controls for channel selection and fine tuning.

The TDN-25-2 comes with its own power supply for under $250. We're hoping to review this rather cute device, but if you can't wait, **Nitec** can be found at **299 Rae St, Nth Fitzroy, Vic, 3068. (03)481-1654.**

Videodisc revolution

In a drive to promote its LaserDisc products, Pioneer has recently been familiarising the public on the advantages of the videodisc medium.

The company says the benefits of videodisc are directly related to its technical features. Each side of a plastic videodisc contains 54,000 individual encoded frames, with each frame storing both picture and sound information. Because videodiscs spin extremely fast on a 'turntable', and because the 'stylus' which scans the discs is a laser beam and makes no mechanical contact with the discs, instant access is possible to any one frame on a disc by a programmable control facility. And the discs suffer no wear and tear.

This huge capacity of pictures per side, plus the durability of the discs, makes videodisc a good medium for information storage. The potential for interactivity made possible by the programming facility means that they are useful as teaching aids.

Pioneer LaserDisc systems are available in three levels of sophistication. Level 1, the 'standalone' mode of operation, is the most basic type of system and might consist of only the LaserDisc player, a video monitor and sound reproduction equipment.

Level 2 contains LaserDisc players designed for self-paced comprehension in retail and teaching situations. These players have their own internal microprocessors which control pre-programmed videodiscs designed to perform certain playback sequences and respond to several commands.

In the Level 3 mode the LaserDisc player is further controlled via an external computer, usually a small personal computer. The computer itself contains a program which not only responds to user input and causes the LaserDisc player to perform accordingly but can add a dimension of local information.

Theatre sound from video or TV

GFS Electronic Imports of Mitcham, Vic, has a new 'add-on' device which "provides — dramatically — the illusion of large theatre sound to a home video recorder, television or hi-fi system."

Manufactured by MFJ Enterprises of Mississippi, USA, the Model MFJ-1500 provides this realistic large theatre sound by electronically processing the source signal. The processing includes the introduction of variable time delay and reverberation, characteristics of a large listening environment.

The MFJ-1500 accepts a mono or stereo input and produces single processed as well as unprocessed outputs, both of which can be fed into the two channels of a stereo amplifier.

For users who do not have a stereo system or do not wish to use their stereo for this purpose, the MFJ-1500 has its own built-in 2 watt amplifier. A single speaker is connected to the MFJ-1500 speaker terminals and placed behind the viewing position. This speaker, in conjunction with the TV's speaker, then provides the viewers with the illusion of big theatre sound. GFS claims that it is the aural equivalent of big screen TV and makes the entire room seem several times larger than it really is.

The MFJ-1500 is housed in an eggshell white cabinet with walnut grain sides. It measures 254 mm x 50 mm x 150 mm and operates from 12 Vdc or 240 Vac. GFS is offering a price of $250 plus $14 P & P to customers who quote this article.

If you would like further information contact **GFS Electronic Imports, 17 McKeon Rd, Mitcham, Vic 3132. (03)873-3777.**

New CMOS logic

A new family of advanced CMOS logic circuits that exceeds the performance of Schottky and HCMOS devices has been introduced by Fairchild.

Called FACT (Fairchild advanced CMOS technology), the devices draw three orders of magnitude less power than equivalent Schottky TTL devices, according to Ray Becker of Fairchild.

Power consumption is 0.1 mW per gate at 1 MHz clock frequency, with propagation delays of just 5 ns. Devices will include more than 80 of the widely used industry-standard 54 and 74 series logic circuits.

"As the market for compact, highly integrated computer and electronic equipment has grown, so has the need for the power-saving advantages of CMOS in the logic gates, latches, flip-flops and bus driver circuits that populate circuit boards," Becker said.

"The low-voltage, high-speed operation of FACT introduces new possibilities for battery-operated or battery back-up systems.

"Up to now, CMOS processes have been unable to approach the switching speeds of advanced low-power Schottky devices and the line-driving capabilities of standard Schottky devices. The FACT line surpasses the performance of Schottky through the use of a sub-2 µm process that has been proven for two years in high-performance gate arrays."

Selected FACT circuits, including popular bus driver/transceiver circuits, have TTL-type input thresholds which allow them to be used as exact replacements for standard and advanced low-power Schottky devices.

Australian pacemaker develops own microchip

A microchip to drive the next generation of implantable cardiac pacemakers has been successfully developed by the Australian company, Telectronics.

The new microchip is to be incorporated into the company's next programmable lifesaving device codenamed X92.

Telectronics claims that the microchip is so electronically advanced that it is breaking new ground in control circuitry.

The microchip, smaller than a little fingernail, contains the equivalent of 28,000 transistors, 4500 gates and 96 bytes of RAM. It draws less than one-millionth of an amp of current at its operating frequency of 32 kHz.

Telectronics met all performance requirements within a projected budget of 12,500 man hours and 21 months.

Project manager Donald Darkin said the success was due to the company's "structured design methodology," verifying all design stages by test vector sequences created by in-house software tools.

"Australia imports 10 times as much high technology as it exports. The imbalance is attributable to a failure to invest in the necessary research and development.

"Telectronics and parent company Nucleas have helped reset the balance and got it right the first time with the X92's microchip," said Darkin.

Telectronics currently claims fourth ranking in the world's pacemaker industry. The Nucleus subsidiary has wholly-owned overseas manufacturing subsidiaries in North and South America and Europe and a marketing and service network in 42 countries.

Fast op-amps

A new generation of JFET input operational amplifiers, the MC34080/35080 series, has been introduced by Motorola. These new devices are available in single, dual and quad versions, compensated and decompensated, and offer bandwidth and slew rates that are up to four times greater than previously available industry standard amplifiers.

A combination of JFET and bipolar technologies along with an all-npn output stage and other design features have yielded a fully compensated op-amp family with a gain bandwidth product of 8 MHz and slew rates in excess of 30 V/µs. If a user requires greater speed, then decompensated ($A_{VCL} \geq 2$) versions of the single, dual and quad devices are offered with a gain bandwidth of 16 MHz and slew rates of 60 V/µs.

Most existing op-amps use an npn/pnp pair output stage. The new MC34080/35080 series uses an all-npn output stage which provides a minimum guaranteed peak-to-peak output voltage swing 33% greater than current industry standard op-amps. This type of output stage is capable of driving highly capacitive loads and also reduces open-loop output impedance at high frequencies. The single and dual op-amp versions use an internal trim network which greatly reduces input offset errors.

For more information contact **Motorola** on **(02)438-1955.**

64K and 256K DRAM CMOS controller

INTEL has introduced the first CMOS dynamic RAM (DRAM) controller, a high-performance VLSI chip called the 82CO8. The 82CO8 is designed to easily interface 64K and 256K DRAMs to microprocessors made by Intel and other manufacturers.

The chip requires very low operating currents (both in active mode and in power down mode, during which only the RAM is engaged), making possible a range of low power and battery back-up applications.

The new chip provides all the signals necessary to control 64K and 256K CMOS DRAMs.

The 82CO8 draws less than 30 mA in active mode, allowing a smaller power supply for greater compactness, lower cost and heat. In power down mode only the system RAM receives power (the controller chip refreshes the RAM automatically), reducing current requirements to the mA range.

The VLSI chip conserves circuit board space by replacing as many as 20 discrete devices or numerous MSI or LSI chips, simplifying design and reducing system costs.

It directly addresses and drives up to 1 MB of memory without external drivers.

For further information, contact **Total Electronics, 9 Harker St, Burwood, Vic 3125. (03)288-4044.**

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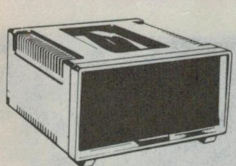

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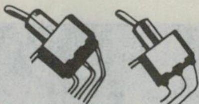

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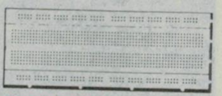

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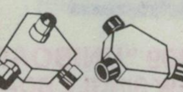
P11012	1280+400 Holes	$36.75
P11015	1920+500 Holes	$57.50
P11018	2560+700 Holes	$64.95



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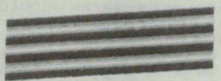
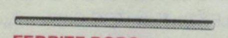


RAINBOW CABLE

Cat.No.	Description	$/metre
W12714	28AWG 14W	$1.80
W12716	28AWG 16W	$1.80
W12720	28AWG 20W	$2.20
W12726	28AWG 26W	$2.90
W12734	28AWG 34W	$3.60
W12740	28AWG 40W	$4.40

12 WAY TERMINAL BLOCKS
P18050 240V 10AMP **$1.50**
P18052 240V 15AMP **$1.75**

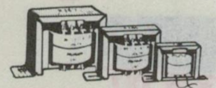


FERRITE RODS
Cat. L11401 **$2.75**

AUSTRALIAN MADE

HIGH EFFICIENCY RADIAL FIN HEATSINK
Black anodised with a thick base plate, this radial fin heatsink can dissipate large amounts of heat for maximum efficiency. Designed by Rod Irving.

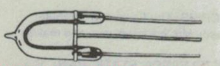
105x65mm	Cat. H10524	$ 2.80
105x75mm	Cat. H10525	$ 3.00
105x150mm	Cat. H10535	$ 5.50
105x225mm	Cat. H10546	$ 8.00
105x300mm	Cat. H10549	$12.00



ECONOMY TRANSFORMERS

	1-9	10+
2155 Cat. M12155	$6.75	$5.95
2156 Cat. M12156	$9.50	$8.95
2851 Cat. M12851	$4.50	$3.60
6672 Cat. M16672	$9.95	$9.30
2860 Cat. M12860	$3.95	$3.80

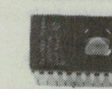
NEW TRANSFORMER!
240V to 15V C.T. at 250 mA
Cat No. M12860
1-9 **$3.95** 10+ **$3.80**



XENON/STROBE TUBES
As used in projects or as replacements
Cat. M14050 **$2.95**

VOLTAGE REGULATORS BARGAINS

Description	1-9	10+
LM309KC	$1.80	$1.60
7805KC	$1.80	$1.60
7812KC	$1.80	$1.60
78405KC	$7.80	$6.95
78H12KC	$7.80	$6.95



WE HAVE THE BEST MEMORY PRICES!

IC SPECIALS!

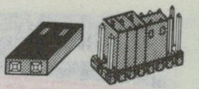
	1-9	10+	100+
4116	$1.80	$1.70	$1.60
4164	$2.95	$2.75	$2.50
2716	$5.90	$5.50	$5.50
2732	$6.25	$5.95	$5.50
2764	$6.25	$5.95	$5.00
27128	$7.00	$6.50	$6.25
6116	$2.95	$2.75	$2.50
41256	$7.00	$6.50	$6.00
6264	$6.50	$5.50	$5.25

TRANSISTOR AND IC's SPECIALS

2N4240	$0.50
MPSA93	$0.25
MJ15004	$2.90
2N4033	$0.30
2N3055	$0.80
2N3772	$2.90
2N3773	$2.90
FND507	$1.00
6845	$6.00
MJ802	$2.90
BF469	$0.40
BF470	$0.40

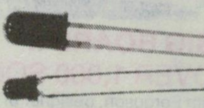
NEW!

FREE STANDING, FOLD UP MAGNIFIER
An economically priced "hands free" magnifier, lets you take care of all those tricky fine detailed jobs so often encountered in electronics, or any of many other practical uses such as home, work, hobbies etc.
Cat. T12083 **$11.95**



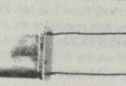
MINI JUMPERS
- Contact terminal: Phospor bronze
- Material: P.B.T. 94V-0
- Gold plated

Qty	Cat. No.	Price
10	P12053	$ 2.95
25	P12055	$ 4.95
100	P12057	$21.95



QUALITY LEDS

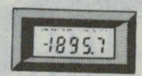
Cat. No.	Description	Price
Z10140	3mm Red	$0.20
Z10141	3mm Green	$0.30
Z10143	3mm Yellow	$0.30
Z10145	3mm Orange	$0.30
Z10150	5mm Red	$0.15
Z10151	5mm Green	$0.30
Z10152	5mm Yellow	$0.30



CRYSTALS SPECIALS
Prime Spec's. We just have too many in stock!

Description	Cat.No.	1-9	10+
1MHz	Y11000	$7.50	$6.50
1.8432MHz	Y11003	$7.50	$6.50
4MHz	Y11020	$2.50	$2.00
4.194304MHz	Y11022	$2.50	$2.00
4.433618MHz	Y11023	$2.50	$2.00
4.75MHz	Y11025	$2.50	$2.00
4.915200MHz	Y11026	$2.50	$2.00
5MHz	Y11030	$2.50	$2.00
6MHz	Y11040	$2.50	$2.00
6.144MHz	Y11042	$2.50	$2.00
6.670MHz	Y11045	$2.50	$2.00
8MHz	Y11050	$2.50	$2.00
8.867238MHz	Y11055	$2.50	$2.00
10MHz	Y11060	$2.50	$2.00
12MHz	Y11070	$2.50	$2.00
14.31818MHz	Y11072	$2.50	$2.00
15MHz	Y11075	$2.50	$2.00
18MHz	Y11082	$2.50	$2.00
18.432MHz	Y11085	$2.50	$2.00
20MHz	Y11090	$2.50	$2.00

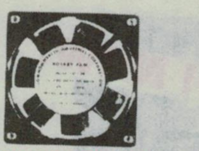
RCA GOLD PLATED PLUGS AND SOCKETS
For those who need the ultimate in connection. Essential for laser disc players to get that fantastic sound quality.
Plug Cat. P10151 **$2.95**
Socket Cat. P10150 **$2.25**



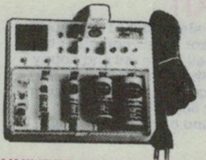
4½ DIGIT LCD DPM 60
- **200mV fsd**
- **Digital Hold**
- **Bandgap Reference**
- **10uV Resolution**

A new 4½ digit LCD DPM offering levels of performance, low current consumption and compact size never previously available. The DPM-60 features Auto-zero, Auto-polarity, a logic switched 200mV or 2V fsd, Digital Hold, programmable decimal points and a 1mA current consumption. Automatic low battery indication and 'continuity' flags are built into the 10mm 4½ digit display. The DPM 60 can be readily rescaled by user to indicate many different units, amps, volts, ohms etc. Supplied complete with fixing bezel, clips and connector, the DPM 60 will suit many applications calling for low-cost, high accuracy measurements in portable instruments or bench instruments.

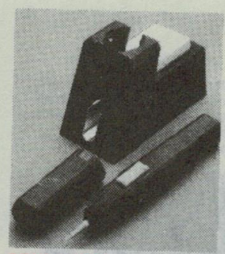
SPECIFICATIONS:
Accuracy: 0.01 m+ −1 digit
Linearity: + −1 digit
Samples/sec: 1.6
Temp. Stability: 50 ppm/°C typical
Temp. Range: 0 - 35°C
Supply Voltage: 7.5 - 15V
Supply Current: 1mA typically
Max DC Input Voltage: + −20V
Cat. Q15520 **$99.95**



BRAND NEW FANS
Not noisy pullouts! Stacks of uses in power amps, computers, hotspot cooling etc. Anywhere you need plenty of air.
240V 4⅝" Cat. T12461 **$12.95**
115V 4⅝" Cat. T12463 **$12.95**
240V 3½" Cat. T12465 **$12.95**
115V 3½" Cat. T12467 **$12.95**
10 Fans (mixed) less 10%



UNIVERSAL BATTERY CHARGER AND TESTER
Save money on expensive batteries with this universal battery charger. Features include meter tester, and provisions for D, C, AA, AAA, N, button and cell batteries, 9V and 6V (square types). Comes complete with detailed instructions.
Cat. M23533 **$24.95**



CORDLESS RECHARGEABLE SOLDERING IRON
- Built in solder point illumination
- Easy replacement of solder tip
- Protective stand which also functions as charging unit
- Sponge pad attach to stand
- Plug pack power adaptor
- Includes Nicad battery
- Instruction manual
- 12 months warranty

Cat. T12480 **$49.95**

VALUE!

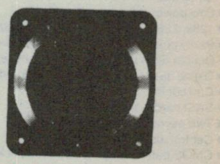
RECHARGEABLE 12V GELL BATTERIES
Leakproof and in 3 convenient sizes, these long service life batteries are ideal for burgular systems, emergency lighting or as a computer backup power supply.
*Ideal for many power needs.
Cat. S15029 12V 1.2 AH **$12.95**
Cat. S15031 12V 2.6 AH **$39.50**
Cat. S15031 12V 4.5 AH **$49.95**

MAGNETIC BULK ERASER
The best and by far the quickest way to erase tapes, cassettes and computer disks! Reduces noise levels below recorders own erase head level. On/Off switch located in handle 240V AC operation.
Cat. C14950 **$29.50**

NEW

MIDRANGE HORNS
Use these quality, all metal, Piezo tweeters for great top end sound in your band speakers, disco sound system, etc. Rated at 30 watts RMS, in a system they will handle over 100 watts RMS.
Two sizes to choose from:
Size: 4"x 10½"
Impedance: 8 ohms
Rating: 30 watts RMS
Response: 1.5kHz - 14 kHz
Dimensions: 102 x 267 x 177mm
Cat. C92082 **$49.95**

Size: 3"x 7"
Impedance: 8 ohms
Rating: 30 watts RMS
Response: 2kHz - 15 kHz
Dimensions: 76 x 177 x 145mm
Cat. C92084 **$29.95**



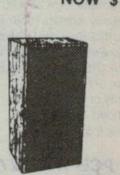
PHILIPS SPEAKERS
"Hopefully, we should have Philips speakers back in stock by the time you read this." -Rod.
Cat. C12030 AD01610 T8 **$12.95**
Cat. C12040 AD02160 SQ8 **$34.95**
Cat. C12045 AD70620 M8 **$49.00**
Cat. C12050 AD12550 W8 **$79.00**
(or Philips equivalent supplied)

SUPER HORN
- Wide dispersion tweeter, handles up to 100W.
- Sensitivity: 105dB/0.5m
- Frequency Response: 3kHz-30kHz
- Impedance: 8 OHMS
- Size: 145x54mm

Cat. C12103 normally $14.95 **NOW $12.95**

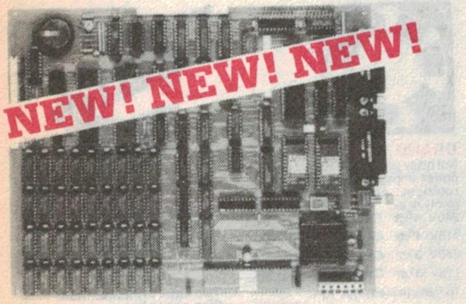
SUPER HORN TWEETER
- Requires no crossover and handles up to 100W!
- Sensitivity: 100dB/0.5m
- Frequency Response: 3kHz-30kHz
- Impedance: 8 OHMS
- Size 96mm diameter

Cat. C12102 normally $14.95 **NOW $12.95**



10W RMS SPEAKERS
Including boxes!! At this price you can afford to put a set of speakers in every room!
Dimensions: H 475 x W 245 x D 200mm
Cat. C12002 **Per Pair $59.50**

Did you know...
Rod Irving Electronics are computer board specialists?!



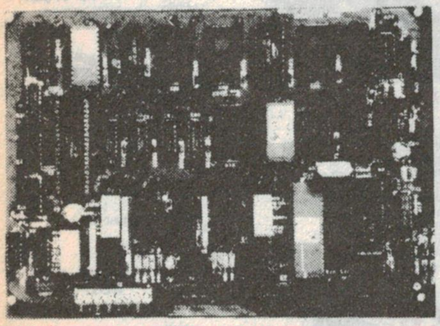
PC 186 KIT

The Positronic Computers PC-186 single board Computer is a general purpose microprocessor based computer that is specifically designed for the small business and hobby computer market.The PC-18 uses the APX 80186-3 (8MHz) or APX 80186-1 (10MHz) microprocessor. By fully utilizing all of the integrated features of the 80816 the PC-186 provides more features than is found on any other single board computer.

FEATURES:

- 80816-3 (8MHz) or 80816-2 (10MHz) central processor
- Small size - only 203mm x 250mm
- Low power requirements
- 128k, 256k, 412, or 1 Mbyte of memory on board
- Parity checking on memory accesses
- Double density Floppy Disc Controller for 8" or 5 1/4" drives
- Digital data separator requiring no adjustments
- Can control Cipher Floppy tape
- SASI hard disk interface
- Two asynchronous serial channels
- Centronics parallel printer adapter
- CMOS battery backed calender clock
- I/O Expansion bus
- 16 Kbytes of EPROM (2764's)
- Diagnostic and bootstrap in ROM

The PC-186 may be purchased as either a mini-kit with only bare PCB and a minimum of necessary components; a full kit with all parts necessary to complete the construction of the PC/186; and as an assembled and tested single board computer.
Please phone (03) 663 6580 for a price.



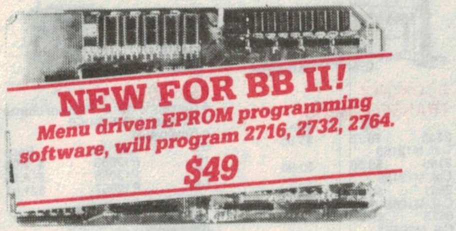
THE NEW ZRT-80 KIT
CRT TERMINAL BOARD!

A LOW COST Z-80 BASED SINLGE BOARD THAT ONLY NEEDS AN ASCII KEYBOARD, POWER SUPPLY AND VIDEO MONITOR TO MAKE A COMPLETE CRT TERMINAL. USE AS A COMPUTER CONSOLE, OR WITH A MODEM OR USE WITH ANY OF THE PHONE-LINE COMPUTER SERVICES.

FEATURES:

- Uses a Z80A and 6845 CRT Controller for powerful video capabilities.
- RS232 at 16 BAUD Rates from 75 to 19,200.
- 24 x 80 standard format (60 Hz).
- Optional formats form 24 x 80 (50 Hz) to 64 lines x 96 characters (60 Hz).
- Higher density formats require up to 3 additional 2K x 8 6116 RAMS. Uses N.S. INS 8250 BAUD Rate Gen. and USART combo IC.
- 3 Terminal Emulation Modes which are Dip Switch selectable. These inlcude the LSI-ADM3A, The Heath H-19, and the Beehive.
- Composite or Split Video.
- Any polarity of video or sync.
- Inverse Video Capability.
- Small Size: 6.5 x 9 inches.

BLANK PCB WITH 2716 CHAR. ROM, 2732 MON. ROM $179
ZRT-80 WITH 8 INCH SOURCE DISK $299
SOURCE DISKETTE, ADD $20
SET OF 2 CRYSTALS, ADD $12



BIG BOARD II
OVER 1,000 SOLD!

Jim Ferguson, designer of the "Big Board" distributed by Digital Research Computers, produced this stunning computer "Big Board II".

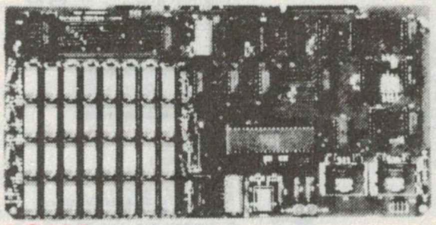
FEATURES:

- **4 MHz Z80 CPU AND PERIPHERALS CHIPS:** The Ferguson computer runs at 4MHz. Its monitor code is lean, uses Mode 2 interrupts, and makes good use of the Z80-A DMA chip.
- **64K RAM + 4K STATIC CRT RAM 24K (E) EPROM STATIC RAM:** "Big Board II" has the three memory banks: the first memory bank has eight 4164 RAM's that provide of user space and 4K of monitor space. The second memory bank has two 2K and 8 SRAMs for the memory-mapped CRT display and space for six 2732s or 2K x 8 static RAMS, or pin compatible (E)PROMs, the third memory banbk is for RAM or ROM added to the board via the STD bus. Whether bought as a bare board, a full Kit, or assembled and tested, it comes with 450nS2732A EPROM containing the monitor.
- **MULTIPLE DENSITY CONTROLLER FOR SS/DS FLOPPY DISKS:** The "Big Board II" computer has a multiple density disk controller, it can use 1793 or 8877 controller chips. The board has two connectors for disk signal with 34 pins for 5 1/4" drives, the other with 50 pins for 8" drives.
- **EXCELLENT ON BOARD VIDEO:** The "Big Board I" computer uses a 6845S CRT controller and 8002 Video Attributes controller to produce a display of quality terminals. Characters are formed by a 5 x 7 dot matrix on 15.75KHz monitors and a 7 x 9 dot matrix on 15.75KHz monitors. The display is user programmable with the default display 24 lines of 80 characters.
- **STD BUS CONNECTOR:** "Big Board II" brings its bus signals to a convenient place on the PC board where users can solder a STD socket, bus cards can be plugged directly into it, and it can as well be connected by bus cable to industry standard card cages.
- **A Z80-A S10/0 = EIGHT PROGRAMMABLE COUNTER/TIMERS:** The "Big Board II" has two Z80-A CTCs. One is used to clock data into and out of the Z80-A S10/0, while the other is for systems and application use.
- **PROM PROGRAMMING CIRCUITRY AND SOFTWARE:** The "Big Board II" computer has circuitry and drivers for programming 2716s, 2732(A)s, or pin-compatible (E)PROMS.
- **CP/M CAPABILITY:** CP/M with Russell Smith's CBIOS for the "BIG BOARD II" is available .... (plus tax) **$230**

The CBIOS 5" or 8" is avail. separately .... (plus tax) **$65**

Cat. K41015 **NOW $595** (plus tax)

Less 10% for 3 or more!! Assem. and Tested **$849** (plus tax)



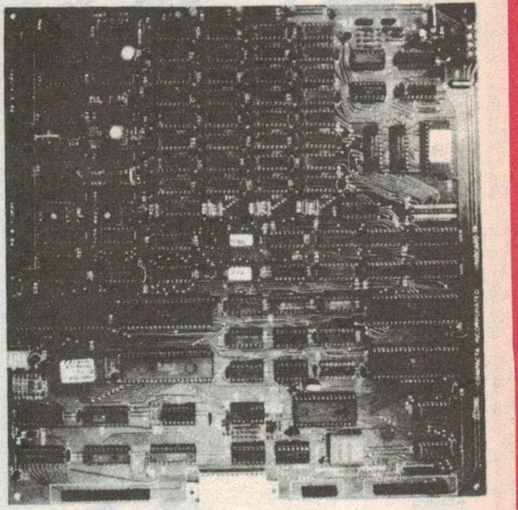
LS100
256K S100 SOLID STATE DISK SIMULATOR

CALLED THE "LIGHT-SPEED 100" BECAUSE IT OFFERS AN OUTSTANDING INCREASE IN YOUR COMPUTER'S PERFORMANCE WHEN COMPARED TO A MECHANICAL FLOPPY DISK DRIVE.

FEATURES:

- 256K on board, using +5V 64K DRAMS
- Uses new Intel 8203-1 LSI Memory Controller
- Requires only 4 dip Switch Selectable I/O Ports
- Runs on 8080 or Z80 S100 slot machines
- Up to 8 LS-100 boards can be run together for 2 Meg of On Line Solid State Disk Storage
- Provisions for Battery back-up
- Software to mate the LS-100 to your CP/M 2.2 DOS is supplied
- The LS-100 provides an increase in speed of up to 7 to 10 times on Disk Intensive Software

Full 256K Kit including Tax **$799**



6809 "UNIBOARD"
NEW SINGLE BOARD COMPUTER KIT!

Many software professionals feel that the 6809 features probably the most powerful instruction set available today on ANY 8 bit micro. Now, at last, all of that immense computing power is available at a truly unbelievably low price.

CHECK THE FEATURES!!!

- 64K RAM using 4116 RAMS.
- 6809E Motorola CPU.
- Double Density Floppy Disk Controller for either 5 1/4 or 8 inch drives. Uses WD 1793.
- On board 80 x 24 video for a low cost console. Uses 2716 Char. Gen. Programmable Formats. Uses 6845 CRT controller.
- ASCII Keyboard parallel input interface. (6522).
- Serial I/O (6551) for RS232C or 20 MA loop.
- Centronics compatible parallel printer interface (6522).
- Buss expansion interface with DMA Channel (6844).
- Dual timer for real clock application.
- Powerful on board system monitor. (2732). Features commands such as Go to, Alter, Fill, Move. Display, or Test Memory. Also Read and Write sectors Boot Normal, Unknown and General Flex.
- PC board is double sided, plated through solder masked, 11 x 11 1/2 inch.
- Includes the powerful 3rd generation Motorola 6809 Processor.

Ideal for colleges, O.E.M.'s, industrial and scientific uses.!

BLANK PC BOARD WITH PAL'S AND TWO EPROMS .... (plus tax) **$239**
5 1/4 OR 8 INCH SOURCE DISKETTE ADD .... **$25** plus tax

COMPLETE KIT, FULLY SOCKETED, ALL OPTIONS ARE STANDARD, NO EXTRAS TO BUY .... **$599** including tax

Cat. Please allow 4 weeks for delivery.

YOUR CHOICE OF POPULAR DISK OPERATING SYSTEMS.

FLEX tm from TSC Cat. **$359**
OS9 tm from Microwave Cat. **$459**
(Please specify 5 1/4 or 8 inch)

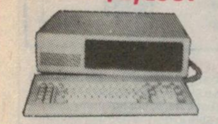
D CONNECTORS

Cat. No.	Description	Price
P12166	9 pin Plug Crimp	$ 9.50
P12167	9 pin Skt Crimp	$ 9.95
P12168	15 pin Plug Crimp	$10.95
P12169	15 pin Skt Crimp	$11.95
P12170	25 pin Plug Crimp	$12.95
P12171	25 pin Skt Crimp	$13.95

CENTRONICS

Cat. No.	Description	Price
P12200	36 way plug IDC	$12.50
P12201	36 way skt IDC	$13.50
P12203	50 way plug IDC	$14.50
P12204	50 way skt IDC	$15.50
P12207	24 way solder plug	$12.90
P12210	36 way solder plug	$ 9.50
P12211	36 way sldr line skt	$15.95
P12213	36 way sldr chss skt	$15.95

IBM* COMPATIBLES from $1,495!



Incredible deals to suit everyone including our special package deals!

256K RAM: Colour Graphics, Disk Controller Card, 1 parallel port, 2 disk drives and 3 months warranty. **only $1,495**

640K RAM: Colour graphics, Multifunction Card, Disk Controller Card, 2 serial and 1 parallel ports, 2 disk drives and 3 months warranty. **only $2,100**

256K PACKAGE DEAL: Includes Colour Graphics Card, Multifunction Card, Disk Controller Card, 2 serial and 1 parallel ports. A 120 C.P.S. printer and a monochrome monitor and 3 months warranty! **only $2,400**

640K PACKAGE DEAL: Includes Colour Graphics Card, Multifunction Card, Disk Controller Card, 2 serial and 1 parallel ports. A 120 C.P.S. printer, a monochrome monitor and 3 months warranty! **only $2,500**

*IBM is a registered trademark.

RITRON MULTI PURPOSE MODEM

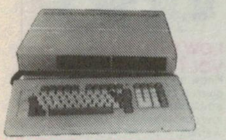
Our New RITRON Multi Purpose Modem has arrived and has all the standards you require.
Just check the Ritron's features:

- CCITT V21 300 Buad Full duplex
- CCITT V23 1200/75
- Bell 103 300 Full duplex
- Bell 202 1200 Half duplex
- Auto answer, auto disconnect.

Telecom Approval No. C84/37/1134 **$379**

APPLE JOYSTICKS

Ideal for games or word processing. Fits most 6502 "compatible" computers.
Cat. C14200 **$29.95**



KEYBOARD AND CASE

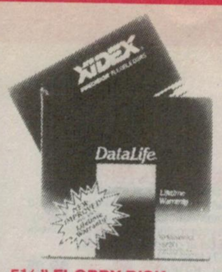
A stylistic low profile case to give your system the professional look it deserves. Comes with an attached encoded, parallel output keyboard and provisions for 2 x 5 1/4" slimline disk drives.
Cat. X11080 **$249**

"IBM AT STYLE" COMPUTER CASING

Our latest computer casing, featuring security key switch, 8 slots, and mounting accessories etc.
Dimensions: 490(W)x145(H)x400(D)
Cat. X11091 **$139**

"IBM PC TYPE" COMPUTER CASING

Give your kit computer a totally professional appearance with one of these "IBM type" casings, includes room for 2 5 1/4 inch disk drives, connection ports and mounting accessories etc.
Dimensions: 490 x 390 x 140mm
Cat. X11090 **$119**



5 1/4" FLOPPY DISK SPECIALS!

		1-9	10+
XIDEX			
S/S D/D	Cat C12401	$31.00	$29.00
D/S D/D	Cat C12410	$38.95	$36.50
VERBATIM DATALIFE			
S/D D/D	Cat. C12501	$27.95	$26.95
D/D D/D	Cat. C12504	$39.95	$37.95
VERBATIM VALULIFE			
S/D D/D	Cat. C12421	$24.95	$22.95
D/D D/D	Cat. C12425	$31.95	$29.95

3 1/2" XIDEX DISKETTES!

Yes, that's right, we now have 'hard to get' 3 1/2" diskettes!
Cat. C12600 S/S box of 10 **$65.95**
Cat. C12602 D/S box of 10 **$89.95**

DELUXE 5 1/4" DISK STORAGE UNIT

Features...

- Clear smoked plastic lid
- Diskette fan display system elevates the disks for easy identification and access.
- Lockable lid (2 keys supplied)
- High impact plastic base
- 45 diskette capacity

Cat. C16050 **$49.50**

MINI DISK STORAGE BOX

Holds up to 30 x 5 1/4" diskettes.
Cat. C16020 **$16.95**

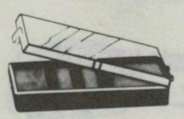
COMPUTER CASSETTES

Quality 20 minute tapes.
Cat. D11141

1-9	10+	100+
$1.00	**$0.90**	**$0.80**

TELEPHONE EXTENSION CABLE UNIT

Allows 15 metres of telephone extension cable to be neatly wound into a protable storage container. The reel sits on a squared off base and the reel has a handle to wind cable back on to it after use. No tangles - no mess! Ideal for the workshop, around the house, office pool etc.
Cat. Y16013 **$24.95**



IC STORAGE CASE

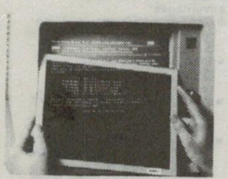
Electro static charge proof plastic IC case with conductive sponge.
Dimensions: 75 x 130 x 19mm.
Cat. H10095 **$5.95**

NEW TTL MONITORS

Fantastic resolution! Enjoy a crisp, sharp image with these new Ritron TTL monitors! IBM* compatible, green display, swivel and tilt base.
Cat. X14510 **$265**

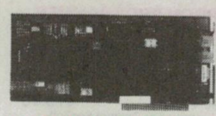
RITRON 1

Our most popular model in a steel cabinet to minimise R.F.I.
Green Cat.X14500 **Save $30 $169**
Amber Cat.X14502 **Save $30 $179**



XIDEX PRECISION SCREEN

Headaches, fatigue and tired eyes are a common complaint from users of CRT's. But studies have reported that the use of the Xidex Precision Screen, actually increases effeciency 20% while relieving eye strain, headaches and general fatigue.
Available in two sizes:
7 7/8"x10 1/2" Cat.X99997 **$49.95**
8 1/2"x11" Cat.X99999 **$49.95**



IBM COMPATIBLE CARDS

MULTIFUNCTION CARD
(384K RAM) Parallel, serial and game port. Plus battery backup clock.
Cat. X18013 **$329**

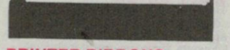
DISK CONTROLLER CARD
Controls 2 slimline drives
Cat. X18005 **$149**

HIGH RESOLUTION MONOCHROME GRAPHICS CARD
Give your IBM real graphics capability.
Cat. X18007 **$249**

512K RAM CARD
(Includes RAM)
Cat. X18015 **$299**

ADD ON HARD DISK DRIVE FOR IBM

Includes disk controller card. Available and installed free only at our city store.
Cat. X20010
10 M Byte **$1,195**
20 M Byte **$1,350**

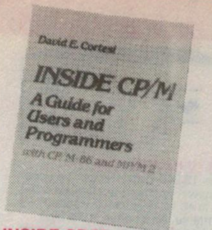


PRINTER RIBBONS

CP80, BX80, DP80, BX100, MB100
$9.90

TDK VIDEO TAPES AT BARGAIN PRICES!

VHS:	E60	$12.50
	E120	$12.50
	E180	$11.80
	E240	$22.40
BETA:	L250	$13.50
	L500	$14.40
	L750	$17.50



INSIDE CP/M

A Guide for users and programmers with CP/M-86 and MP/M2, by David Cortesi.
This book is both a guide and a reference manual for CP/M, an operating system for small computers. The book has two sections. The Tutorial presents the basics of the management, use, and programming of a small computer and CP/M. In the Reference, CP/M information is organised for quick access by programmers and users. **$47.50**

Rod Irving Electronics, No.1 for peripherals!

180 CPS PRINTER! KAITEC KAI 180 EX

Standard 80 column Dot Matrix Printer. High quality printing by NLQ mode. 3K Buffer. High-speed, low-energy consumption 9 wire dot head allows 180 characters per second.
Logic seeking printing or incremental printing with high response, stepping motor. Use of fan-fold, roll or cut-sheet paper is possible with adjustable sprocket pin feed and friction feed. Both fixed and proportional character pitches are available. Emphasized and double print modes are possible. 9 graphic modes are available. 8 language international character font internalized.

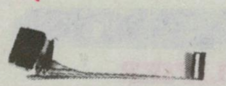
SPECIFICATIONS:
Printing Type: Impact Dot Matrix
Maximum Printing Range: 203mm
Print Types: ASCII 96 Others 7 language
Character Format: Character Mode Standard 9 x 9 dots NLQ 18 x 20 dots Graphic Mode
Printer Modes: (a) Fixed pitch mode (b) Proportional pitch mode
Character Size: 2.42(H)x 1.99(W)
Printing Speed: 180 Character per sec. (pica)
Paper Feed Method: (a) Adjustable sprocket pin feed paper width 4-10 inch (pull through) (b) Friction feed paper width 4-8.5 inch
Interface: Parallel interface 8-bit parallel (Conforms to Centronics)
Cat. C20020 **Only $499**

TDK AUDIO TAPE BARGAINS

Description	Cat. No.	1-9	10+
DC46 TDK	A11305	2.75	2.10
DC60 TDK	A11307	2.95	2.25
DC90 TDK	A11309	3.50	2.50
DC120 TDK	A11311	5.50	4.25
AD60 TDK	A11315	3.75	2.95
AD90 TDK	A11317	4.75	3.50
AD120 TDK	A11319	6.95	5.50
ADX60 TDK	A11320	4.95	3.50
ADX90 TDK	A11322	5.95	4.50
SA60 TDK	A11325	5.35	3.95
SA90 TDK	A11327	5.95	4.50
SAX60 TDK	A11329	5.25	3.95
SAX90 TDK	A11332	6.95	5.95
MAC60 TDK	A11335	10.95	9.35
MAC90 TDK	A11337	11.50	8.75
MAR60 TDK	A11340	13.50	10.95
MAR90 TDK	A11342	17.20	15.35

THE 'C' PROGRAMMER'S HANDBOOK

This handbook is an introduction and a reference to the C programming language, both for beginning and experienced programmers. C is a general purpose language featuring economy of expression, and modern flow control and data structures. Concise structure and fast execution make C the ideal language for applications and system-level programming. **$27.50**



COMPUTER LEADS

We have a wide range of computer leads available, all at very reasonable prices!

APPLE:

- Apple II, IIe, II+, with parallel interface card
- Dual 10 pin (20 contacts) connector to Centronics 36 pin plug
- Length 2.4 metres

Cat. P19025 **$24.95**

IBM

- IBM PC, XT, and look alikes with 25 pin "D" plug on computer end to Centronics 36 pin plug on printer end.
- Length 2.1 metres

Cat. P19029 **$34.95**

TANDY

- For models II/12/16/16B/2000, with dual 17 pin female on computer end to Centronics 36 pin plug on printer end. (Equivalent to 26-1323)
- Length 2.4 metres

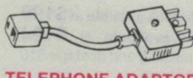
Cat. P19027 **$29.95**

- For models I/III/4/4P, with 34 pin edge connector on computer end to Centronics 36 pin plug on the printer end. (Equivalent to 26-1401)
- Length 2.4 metres

Cat. P19028 **$32.50**

NEW PHONE PLUGS & SOCKETS

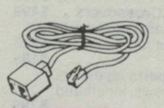
We hear on the grapevine that all future installation will use the U.S.A type of plug and sockets for communication lines.



TELEPHONE ADAPTOR

- Australian plug to U.S. socket
- Length 10cm
- Cream colour cable

Cat. Y16026 **$6.95**



TELEPHONE EXTENSION CABLE

- U.S. plug to 2 U.S. sockets
- Length 10 metres
- Cream colour cable

Cat. Y16028 **$10.95**

COMPUTER CHESS! by SciSys.

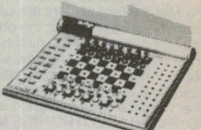
SciSys computer chess games are endorsed by Garry Kasparov, world's highest rated chess player, and are available from Rod Irving Electronics!

TURBO 16K

This brand new chess computer sets new standards in user convenience, and beats 92% of all chess players with its powerful 16K program.
Features:
Instant response

- Solves mate in 10 moves
- Internal clock with 2 LCD displays
- Displays moves considered
- Thinks in opponent's time
- Takes back
- 17 Levels
- 2 Year memory
- Mains adaptor socket

Cat. C30010 **$295**



EXPRESS 16K

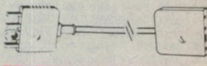
Instant response hand held chess computer.

- Instant response - uses opponents thinking time to prepare instant replies to several alternative opponent moves.
- Strong program beats 90% of all chess players (estimated SciSys-Elo 1800.)
- Automatic Display Move function
- Extra flat. High-value metallic finish.
- Fast 8 MHz 16K chip.
- 17 playing levels: 1 beginner, 8 casuals, 6 club, 2 special (analysis and problem to Mate in ten moves)
- Very long battery life, 1000 hours playing, one year memory.

Cat. C30006 **$199**

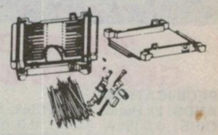
3 IN 1 GAMES

CHESS, TIC TAC TOE, AND CHECKERS!
CHESS: 8 levels, solves up to mate in 4 moves.
TIC TAC TOE: 4 levels of skill, big easy to use pieces, quick response, take back facility.
CHECKERS: 8 levels of skill, take back facility.
Perfect for the whole family!
Cat. C30008 **$149**



TELECOMMUNICATION EXTENSION LEADS

Cat. Y16010 5 metre **$12.50**
Cat. Y16012 10 metre **$14.95**



RS232 MINI PATCH BOX

- Interface RS232 devices
- With male to female 25 pin inputs
- 25 leads with tinned end supplied
- Complete with instructions

Cat. X15654 **$25.95**

COMPUROBOT

Simply key in a list of commands to the amazing Compurobot and watch him go about performing even your most complex manuevers - up to 48 steps! Forward, backward, left/right turn, left/right curve, robot noises, flashing lights and a multi speed gearbox!
Cat. **$49.50**

SERIES 5000

INDIVIDUAL COMPONENTS TO MAKE UP A SUPERB HIFI SYSTEM!

By directly importing and a more technically orient... organisation ROD IRV... we also ... assembled and tested.

WHILE OUR CURRENCY IS DEVALUING PRICES WILL RISE, SO BE QUICK!

POWER AMPLIFIER

WHY YOU SHOULD BUY A "ROD IRVING ELECTRONICS" SERIES 5000 POWER AMPLIFIER....

- 1% Metal Film resistors are used where possible.
- Alumimium case as per the original article.
- All components are top quality.
- Over 1000 of these kits now sold.
- Super Finish front panel supplied at no extra cost.

Please note that the "Superb Quality" Heatsink for the Power Amplifier was designed and developed by ROD IRVING ELECTRONICS and is being supplied to other kit suppliers.

SPECIFICATIONS: 150 W RMS into 4 ohms
POWER AMPLIFIER: 100W RMS into 8 ohms (+ −55V Supply)
FREQUENCY RESPONSE: 8Hz to 20Hz +0= 0.4 dB 2.8Hz to 65KHz, +0=3 dB. NOTE: These figures are determined solely by passive filters.
INPUT SENSITIVITY: 1 V RMS for 100W ouput.
HUM: 100 dB below full output (flat).
NOISE: 116 dB below full output (flat, 20KHz bandwidth).
2nd HARMONIC DISTORTION: ‹0.001% at 1 KHz (0.0007% on Prototypes) at 100W ouput using a + =56V SUPPLY rated at 4A continues ‹0.0003% for all frequencies less than 10KHz and all powers below clipping.
TOTAL HARMONIC DISTORTION: Determined by 2nd Harmonic Distortion (see above).
INTERMODULATION DISTORTION: 0.003% at 100W. (50Hz and 7KHz mixed 4:1).
STABILITY: Unconditional.

Cat. K44771 **Will be $359, limited stock available at $339**
Assembled and tested $549
packing and post $10

PREAMPLIFIER

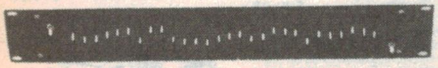
THE ADVANTAGES OF BUYING A "ROD IRVING ELECTRONICS" SERIES 5000 PREAMPLIFIER KIT ARE....

- 1% Metal Film Resistors are supplied.
- 14 Metres of Low Capacitance Shielded Cable are supplied (a bit extra in case of mistakes).
- English "Lorlin" switches ae supplied (no substitutes here.)
- Specially imported black anodised aluminium knobs.

Available Assembled and Tested. (We believe that dollar for dollar there is not a commercial unit available that sounds as good!)

SPECIFICATIONS:
FREQUENCY RESPONSE: High-level input: 15Hz = 130KHz, +0, =1dB
Low-Level input-conforms to RIAA equalisation + = 0.2dB
DISTORTION: 1KHz ‹0.003% on all inputs (limit of resolution on measuring equipment due to noise limitation).
S/N NOISE: High-Level input, master full, with respect to 300mV input signal at full output (1.2V) › 92dB flat › 100dB A-weighted. MM input, master full, with respect to full output (1.2V) at 5 mV input 50ohms source resistance connected: ›86dB flat/92dB A-weighted MC input, master full, with respect to full output (1.2V) and 200uV input signal: ›71dB flat ›75dB A-weighted.

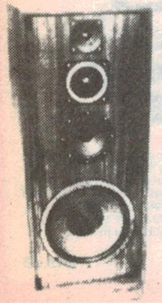
Cat. K44791 **Will be $319, limited stock availble at $299**
Assembled and tested $599
packing and postage $10



THIRD OCTAVE GRAPHIC EQUALIZER

SPECIFICATIONS:
BANDS: 28 Bands from 31.5Hz to 16KHz.
NOISE: ‹0.008mV, sliders at 0, gain at 0(=103dB0).
20KHz BANDWIDTH DISTORTION: 0.007% at 300mV signal, sliders at 0, gain at 0, maximum 0.01%, sliders at minimum.
FREQUENCY RESPONSE: 12Hz = 105KHz, +0, =1dB, all controls flat.
BOOST AND CUT: 14dB

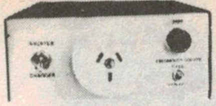
Cat. K44590 1 unit: **will be $219, limited stock availble at $199**
2 unit: **will be $429, limited stock available at $194**
packing and postage $10



SERIES 4000 SPEAKERS

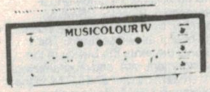
8 Speakers On	$295
8 Speakers with Crossovers	$499
Speaker Boxes (assembled with grill and speaker cutout)	$325
Crossover Kits	$199
Complete kit of parts (speakers, crossovers, screws, innerband boxes.)	$799
Assembled, tested and ready to hook up to your system	$895

Errors and Ommissions Excepted



40 W INVERTER

This 12 240 V inverter can be used to power up mains appliances rated up to 40 W, or to vary the speed of a turntable. As a bonus, it will also work backwards as a trickle charger to top up the battery when the power is on. (EA May'82) 82IV5
Cat. K82050 **$57.50**



MUSICOLOR IV

Add excitement to parties, card nights and discos with EAs Musicolor IV light show. This is the latest in the famous line of musicolors and it offers features such as four channel "color organ" plus four channel light chaser, front panel LED display, internal microphone, single sensitivity control plus opto-coupled switching for increased safety.
(EA Aug.'81) 81MC8
Cat. K81080 **$99**

ELECTRONIC MOUSETRAP

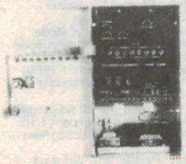
This clever electronic mousetrap disposes of mice instantly and mercifully, without fail, and resets itself automatically. They'll never get away with the cheese again!
(ETI Aug.'84) ETI 1524
Cat. K55240 **$27.50**

VOICE OPPERATED RELAY

EA's great Voice Operated Relay can be used to control a tape recorder, as a VOX circuit for a transmitter or to control a slide projector. (EA Apr '82) 82VX4
Cat. K82043 **$17.95**

STEREO ENHANCER

The best thing about stereo is that it sounds good! The greatest stereo hi-fi system loses its magnificence if the effect is so narrow you can't hear it. This project lets you cheat on being cheated and creates an 'enhanced stereo effect' with a small unit which attaches to your amp.
(ETI 1405, ETI, MAR '85)
Cat. K54050 **$79.50**



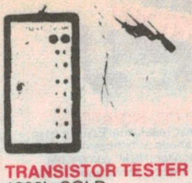
MULTI SECTOR ALARM STATION

The Christmas season always brings with it an increase in home burglaries, so nows the time for installing security equipment. Relieve the boredom, save money, and at the same time protect your home from intruders with this up-to-the-minute burgular alarm system. Its easy to build, costs less than equivalent commercial units, and features eight seperate inputs, individual sector control, battery back up and self-test facility.

Specifications:

- Eight sectors with LED status indication.
- Two delayed entry sectors.
- Variable exit, entry and alarm time settings: entry delay variable between 10 and 75 seconds; exit delay variable between 5 and 45 seconds; alarm time variable between 1 and 15 minutes.
- Resistive loop sensing: suits both normally open and normally closed alarm sensors.
- Battery back-up with in-built charger circuit.
- Built-in siren driver.

Complete kit including deluxe prepunched metal work and electronics for only...
Cat. K85900 **$129**



TRANSISTOR TESTER

1000's SOLD

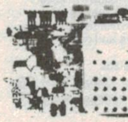
Have you ever desoldered a suspect transistor, only to find that it checks OK? Trouble-shooting exercises are often hindered by this type of false alarm, but many of them could be avoided with an "in-circuit" component tester, such as the EA Handy Tester. (EA Sept.'83) 83TT8
Cat. K83080 **$17.95**

300 BAUD DIRECT CONNECT MODEM

Modem? What do I want with a modem? Think of these advantages:

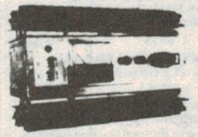
- Can't afford a floppy disc? Use your telephone to access one for the cost of a call.
- Bored with your old programs? Download hundreds of free programs.
- Want to get in touch with fellow computer enthusiasts? Use 'electronic mail'.
- Ever used a CP/M system? CP-DOS? UNIX? Well a modem will make a your computer a remote terminal on some of the most exciting systems around.

Save on ready built modems.
Cat. K97050 **$119**
(Short form without phone)



EPROM PROGRAMMER EP1

No need for a Micro with EA's great Eprom Programmer suitable for 2716/2758 Eproms.
(EA Jan.'82) 82EP1
Cat. K82013 **$79.95**
(Including Textool Socket)



ELECTRIC DUMMY LOAD

With this unit you can test power supplies at currents up to 15 Amps and voltage up to 60 Volts. It can "sink" up to 200 Watts on a static test and you can modulate the load to perform dynamic tests.
(ETI Oct.'80) ETI 147
Cat. K41470 **$119**

ELECTRONIC WATT METER

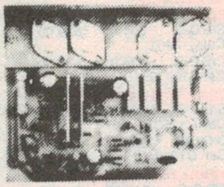
This unit will measure the power consumption of any mains appliance with a rating up to 3 kilowatts. It makes use of a special op amp called an 'output transconductance amp' or OTA. for short.
(EA Sept.'83) 83WM8
Cat. K83082 **$89.95**

30 V/1 A FULLY PROTECTED POWER SUPPLY

The last power supply we did was the phenomenally popular ETI-131. This low cost supply features full protection, output variation from 0V to 30V and selectable current limit. Both volatage and current metering is provided. (ETI Dec. 83) ETI 162
Cat. K41620 **$52.50**

ZENER TESTER

A simple low cost add-on for your multimeter. This checks zeners and reads out the zener voltage directly on your multimeter. It can also check LEDs and ordinary diodes.
(ETI May'83) ETI 164
Cat. K41640 **$9.95**



MOSFET POWER AMPLIFIER

Employing Hitachi Mosfets, this power amplifier features a 'no compromise' design, and is rated to deliver 150 W RMS maximum and features extremely low harmonic, transient and intermodulation distortion.
ETI 477 (ETI Jan.'81)
(Single module only)
Cat. K44770 **$79.50**
Plus power supply (No trans) **$49**
Plus transformer PF4361/1 **$49.50**

PARALLEL PRINTER SWITCH

Tired of plug swapping when ever you want to change from one printer to another? This low-cost project should suit you down to the ground. It lets you have two Centronics-type printers connected up permanently, so that you can select one or the other at the flick of a switch.
(ETI 666, Feb. '85)
Cat. K46660 **$79.95**

50 W AMPLIFIER MODULE (ETI 480)

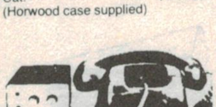
Cat. K44880 **$27.50**
(Heatsink optional extra)

100 W AMPLIFIER MODULE (ETI 480)

Cat. K44801 **$29.95**
(Heatsink optional extra)

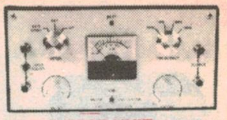
EPROM PROGRAMMER

If you have ever wanted to rewrite or extend the operating system of your microcomputer or if your're interested in dedicated microprocessor applications then this EPROM Programmer is just the thing. It is an inexpensive unit that uses readily available IC's, interfaces directly to the expansion bus on the back of all the popular 8080/Z80 microcopmputers and programs 2708's, 2716's, 2758's and 2732's. (EA July '80) 80PP71
Cat. **$79.50**
(Horwood case supplied)



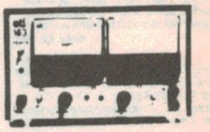
PHONE MINDER

Dubbed the Phone Minder, this handy gadget functions as both a bell extender and paging unit, or it can perform either function separately. (EA Feb.'84) 84TP2
Cat. K84021 **$27.50**



AUDIO TEST UNIT

Just about everyone these days who has a stereo system also has a good cassette deck, but not many people are able to get the best performance from it. Our Audio Test Unit allows you to set your cassette recorder's bias for optimum frequency response for a given tape or alternatively, it allows you to find out which tape is best for your recorder. (81AO10) (EA Oct '81)
Cat. K81101 **$59.95**

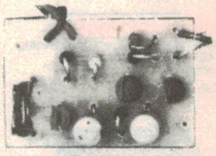


LAB SUPPLY

Fully variable 0-40V current limited 0-5A supply with both voltage and current metering (two ranges: 0-0.5A/0-5A). This employs a conventional series-pass regulator, not a switchmode type with its attendant problems, but dissipation is reduced by unique relay switching system switching between laps on the transformer secondary.
(ETI May'83) ETI 163
Cat. K41630 **$182.50**

300W "BRUTE" AMPLIFIER

The "Brute" develops 300W into 4 ohms, 200W into 8 ohms!
For many aduio applications there's no substitue for sheer power - low efficiency speakers, outdoor sound systems, or maybe you like the full flavour of the dynamic range afforded by a high power amp. Whatever your requirement - this 'super power' module should fill the bill. (ETI 466) (ETI Feb '80)
Cat. K44660 **$89.95**
(Heatsink not included)

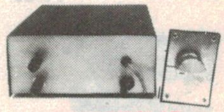


LOW BATTERY VOLTAGE INDICATOR

Knowing your batteries are about to give up on you could save many an embarrassing situation. This simple low cost project will give your early warning of power failure, and makes a handy beginner's project.
(ETI 280, March '85)
Cat. K42800 **$7.95**

HUMIDITY METER

This project can be built to give a readout of relative humidity either on a LED dot-mode display or a conventional meter. In addition it can be used with another project as a controller to turn on and off a water mist spray in a hothouse, for example. (ETI May '81) ETI-256
(Includes humidity sensor $19.50)
Cat. K52460 **$29.50**



LOW-COST BIPOLAR MODEL TRAIN CONTROLLER

Here is a simple model train control for those enthusiasts who desire something better than the usual rheostat control. It provides much improved low speed performance and is fully overload protected, yet contains relatively few componenets. Best of all, you don't need to be an electronic genius to construct it. (80TC12) (EA Dec '80)
Cat. K80120 **$39.95**

ARBITRARY WAVEFORM GENERATOR

Neale Hancock

The standard waveforms typically available for testing and for musical applications are sine, square, triangular and ramp waveforms. Now you can produce waveforms of virtually any shape as well as pulse trains using our arbitrary waveform generator.

IN THE NOT too distant past when I was working with electronic test and measurement instrumentation, I was confronted with an instrument which could be programmed to create waveforms of any shape. This quite intrigued me. The applications of the device included simulation of waveforms, control signal generation and digital bit pattern generation. Instantly I saw it as the best thing since sliced bread due to its inherent flexibility and its potential for generating sound.

My initial interest focused on the sound generating possibilities of this instrument, as it would enable me to 'design' my own waveshape for use in synthesised music. But the multi-thousand dollar price tag lowered my enthusiasm to buy, rather it redirected my interest to finding out how the darned thing worked! To my delight the basic principles were not very complex.

Circuit considerations

The basic principle of operation for an arbitrary waveform generator is to program a block of RAM with binary information which describes a waveform. This information is then read out of the RAM and put through a digital-to-analogue converter to generate an actual waveform.

Thus the major parts of the arbitrary waveform generator are a voltage controlled oscillator (VCO), a block of RAM, digital circuitry to program the RAM with a waveform, and a digital-to-analogue converter. The heart of the circuit is the RAM into which a waveform is programmed. The RAM stores this waveform as digital data eight bits wide up to 1K deep. It is then converted to an analogue signal by feeding it through the digital-to-analogue converter. The VCO is used to cycle the RAM. Changing the frequency of the VCO changes the frequency of the output waveform. Figure 1 illustrates in the form of a block diagram, how these main parts of the circuit fit together.

The RAM can be programmed using a variety of techniques. One of these involves using a microprocessor and PROM based software (this is used in commercially available arbitrary waveform generators). Another method involves using counters to generate ramps of different slopes as well as steps. The latter approach appealed more to me as it was cheaper and quicker to design. But the trade off is that we forfeit the flexbility which is achieved using a microprocessor.

To program ramps into the RAM two binary counters are used, one of which is the address counter and the other is a data counter. Since the RAM is 1K deep by eight bits wide (1K byte), the address counter must be able to count up to 1024 (10 bits) and the data counter must be able to count up to 256 (8 bits). The horizontal component of the ramp is generated by the address counter and the vertical component of the ramp is generated by the data counter. Therefore a slope of 1:1 is generated if the two counters are driven by a common clock.

To generate ramps of different slopes the counters can be clocked at different rates; for example, if a slope of 2:1 is required the horizontal counter is clocked at half the rate of the vertical counter. This can be achieved by dividing the clock signal going to the address counter by two, using a J-K flipflop. The same applies for a slope of 4:1; this time two J-K flipflops are used to divide the clock signal. Ramps having slopes of 1:2 and 1:4 can also be achieved by swapping the clock signal going to the data counter with the clock signal going to the address counter.

Both positive and negative gradient slopes are achieved by using the data counter to either count up or count down. Vertical steps are achieved by disabling the address counter and allowing the data counter to count up, thus creating the rising edge of a pulse, then allowing it to count down to create the trailing edge of the pulse. Horizontal steps are created by disabling the vertical counter.

All of the above division and switching is represented in the block labelled "divider and switching" in Figure 1.

So that the ramps and steps can be given a finite length or 'height' the binary output from the counters is compared to a binary value set by the programming switches. A multiplexer is used to select which counter output is to be compared with the switches. When the output from the counter is the same as the switch setting, the counter is stopped, thus terminating the ramp or step at the desired point.

When the waveform is being read out of the RAM the comparator is used to cycle only the area of memory in which the waveform is present. For example if the waveform only occupies the RAM up to address 700, the programming switches can be set such that the RAM is cycled only up to that point. By reducing the amount of memory being cycled higher frequency waveforms can be generated. For instance if 1K of memory is being cycled by a 3 MHz clock, the cycle rate of the memory is 3 kHz.

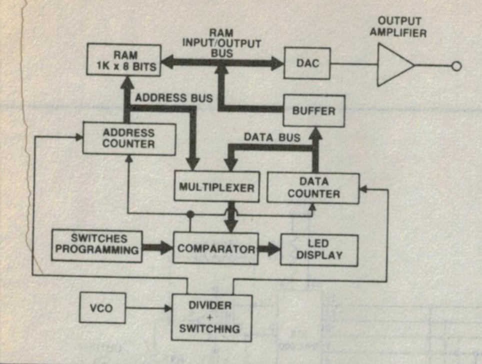


Figure 1. A block diagram of the arbitrary waveform generator.

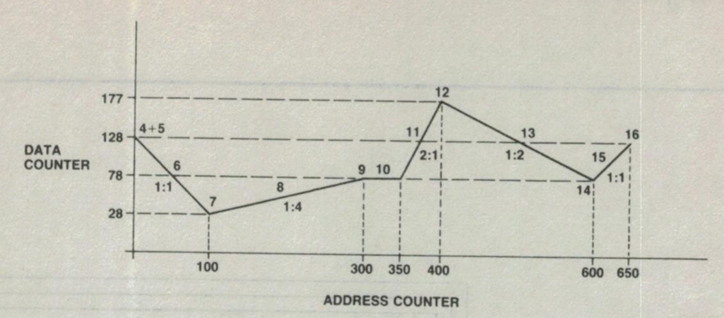


Figure 2. An illustration of the arbitrary waveform described in Table 1.

Therefore, the fastest waveform available from the generator is 3 kHz if the 1K of memory is programmed with one cycle of the waveform. But if the waveform occupies only a quarter of the memory and only that quarter is cycled, the output waveform can be output at four times the speed. In this case, the waveform would be output at 12 kHz. Of course this additonal speed is at the expense of waveform resolution.

Construction

Before you commence construction, check the pc board for broken tracks. If you find any broken tracks reconnect them by soldering a short length of wire over the break. The best way to do this is by melting a small amount of solder on to the area where the break is. Next take the wire and 'wet' both ends of it with solder and hold it in place on the break with some tweezers, then solder it into place. By wetting the wire with solder first, you can get it soldered into place without having to grow a third hand and avoid solder bridges from excess solder. Also check that no pads have been cut in half by drill holes. This is critical because some tracks connect to both ends of the pads.

Commence construction by mounting all the diodes on the board, checking their orientation against the overlay first. Mount the capacitors next, but make sure that the three 1000 μF electrolytic capacitors (C6, C8 and C9) and the three 10 μF tantalum capacitors (C7, C10 and C11) are polarised correctly. Remember to clip the leads of all the components as short as possible after you have soldered them in.

The 5, 12 and −12 volt regulators can now go in. Before you mount the 5 volt regulator bolt the heatsink to it and use some heatsink compound to allow better thermal conductivity between the two. Note that the 5 volt regulator (IC21) has a pin which requires soldering on both sides of the pc board. Solder in all the resistors, note that R2 requires one of its pins soldered on both sides of the pc board. Now solder in the pin-through located between IC6 and IC8.

Solder in all the integrated circuits with the same orientation, that is with the pin 1 end pointing toward the diode bridges. Take care not to use too much solder on the pads, as some of them have tracks running between them. Some of these ICs require their pins soldered on both sides of the pc board so look out for them; the overlay will assist here.

The pc board should now be put aside while you drill mounting holes in the case for the switches, the transformer, the potentiometers and the pc board. Drill the front panel as outlined in the drilling diagram. If any of the holes are too small use a round file or a reamer to make them a suitable size. Drill a row of 3 mm holes in the panel where the display is to be mounted. Connect these holes using a file, then use a flat file to make the slot the same size as the LED display. The tighter the display fits in the slot the easier it is to mount.

The mounting holes for the pc board, the transformer and the cable tie can now be drilled. The holes for the pc board should be 3 mm in diameter and the holes for the transformer and cable tie should be 4 mm in diameter. Also drill an 8 mm hole in the back panel for the power cord.

If you are putting a Scotchcal front panel on the case it should be done now. Begin by filing any burrs off the front panel and make sure that it is clean. Peel the backing paper off the Scotchcal, line it up with the front panel and stick it on. Carefully ream out holes in the Scotchcal for the switches and potentiometers and use a sharp blade to cut a slot in it for the display.

The rotary switches, the toggle switches, the potentiometers and the output socket can now be mounted on the front panel. The wiring details and mounting orientation of the components on the front panel are shown overleaf. Bare hookup wire can be used to connect the poles of the programming switches (SW6 to SW15) together. When connecting the cathodes of the LEDs together you can also use bare hookup wire, providing the LED leads are kept short.

The flying leads connecting these switches and LEDs to the pc board should be about 130 mm in length. To avoid confusion you should use different coloured wire for making these connections to the pc board. The wires should be grouped as to their destination, so, for example, all the leads going to IC11 should be grouped in one cluster, those going to IC10 in another, etc. By grouping and taping the leads into clusters you can prevent the inside of your box looking like a rat's next.

The flying leads connecting the potentiometers, the transformer and the rest of the switches to the pc board can now be connected up. The leads from SW4 should also be grouped as they are all destined for the same area of the pc board. Try to group the rest of the wires where possible to keep the inside of the box tidy.

When you are connecting the power cord to the on/off switch and connecting the on/off switch to the transformer, be sure to insulate the terminals both on the switch and on the transformer. Also use a cable tie or some strong tape to hold the active and the neutral power leads together. The earth lead of the power cord must be connected to the case of the generator.

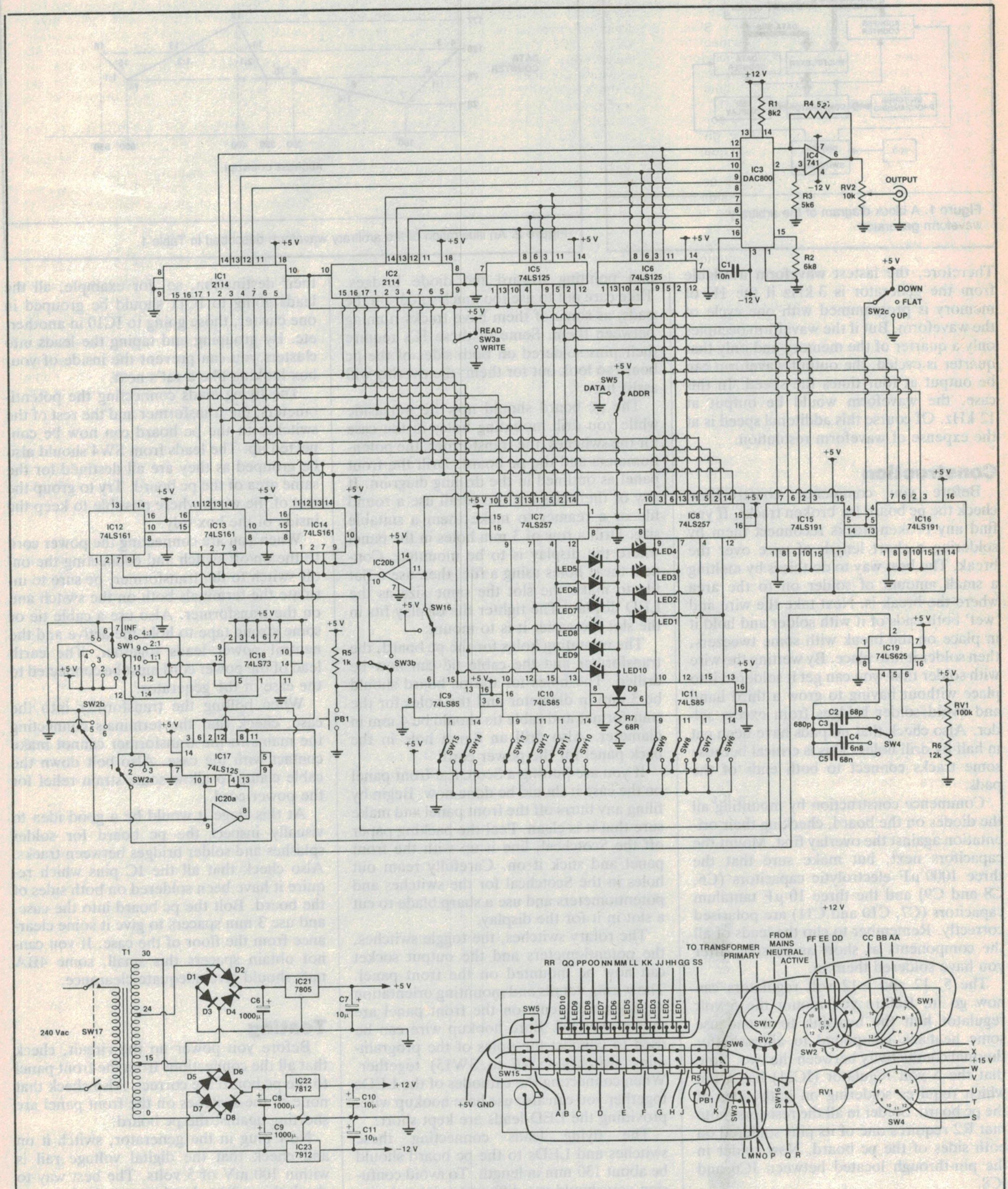
When bolting the transformer into the case, check that the terminals connecting the mains to the transformer cannot make contact with the case. Also bolt down the cable clamp to allow some strain relief for the power cord.

At this stage it would be a good idea to visually inspect the pc board for solder splashes and solder bridges between tracks. Also check that all the IC pins which require it have been soldered on both sides of the board. Bolt the pc board into the case, and use 3 mm spacers to give it some clearance from the floor of the case. If you cannot obtain spacers this small, some 4BA nuts should give adequate clearance.

Testing

Before you power up the circuit, check that all the connections from the front panel to the pc board are correct. Also check that none of the switches on the front panel are shorting against the pc board.

Now plug in the generator, switch it on and check that the digital voltage rail is within 100 mV of 5 volts. The best way to check this voltage level is to probe between pin 16 of IC16 and the case. Also check the +12 and −12 volt rails. The +12 volt rail ▶


IC1 2114
IC2 2114
IC3 DAC800
IC4 741
IC5 74LS125
IC6 74LS125
IC7 74LS257
IC8 74LS257
IC9 74LS85
IC10 74LS85
IC11 74LS85
IC12 74LS161
IC13 74LS161
IC14 74LS161
IC15 74LS191
IC16 74LS191
IC17 74LS125
IC18 74LS73
IC19 74LS625
IC20a
IC20b
IC21 7805
IC22 7812
IC23 7912
+12 V
R1 8k2
R4 5k6
R3 5k6
R2 6k8
RV2 10k
OUTPUT
C1 10n
-12 V
+5 V
READ
SW3a
WRITE
SW5
DATA
ADDR
SW2c
DOWN
FLAT
UP
LED1
LED2
LED3
LED4
LED5
LED6
LED7
LED8
LED9
LED10
D9
R7 68R
R5 1k
SW3b
SW16
PB1
SW1
INF
SW2b
SW2a
C2 68p
C3 680p
C4 6n8
C5 68n
SW4
RV1 100k
R6 12k
T1
240 Vac
SW17
D2
D3
D4
D5
D6
D7
D8
C6 1000μ
C7 10μ
C8 1000μ
C9 1000μ
C10 10μ
C11 10μ
+5V GND
TO TRANSFORMER PRIMARY
FROM MAINS NEUTRAL ACTIVE
FF EE DD
CC BB AA
RR QQ PP OO NN MM LL KK JJ HH GG SS
A B C D E F G H J
K L M N O P Q R
SW15
SW6
SW14
SW13
SW12
SW11
SW10
SW9
SW8
SW7
SW2
SW3
RV1
RV2
X
+15 V
W
V
U
T
S

HOW IT WORKS — ETI-171

The voltage controlled oscillator IC19 provides clocking signals for the circuit. Capacitors C2, C3, C4 and C5 set the frequency range and are selected by SW4. Resistor R6 and RV1 set the intermediate frequencies within the range. Therefore SW4 is labelled coarse frequency adjust and RV1 is labelled fine frequency adjust.

The output from IC19 goes to ICs 17 and 18. IC18 is a dual J-K flip flop and is configured to act as a frequency divider giving outputs which are one half and one quarter the clock frequency.

The outputs from IC18 are selected using SW1 and as these divided clock signals determine the slope of the ramps (see text) SW1 is labelled SLOPE on the front panel. IC17 is used to swap over the clock signals going to the address and data counters; poles 1 to 6 of SW1 control the signal which enables the switching of IC17. SW2a and SW2b allow flat steps to be implemented by disconnecting the clock from the data counter.

ICs 12, 13 and 14 are the address counter chips and are cascaded to form a 10-bit counter. ICs 14 and 13 count the eight least significant bits, IC12 counts and the two most significant bits.

ICs 15 and 16 are the data counter chips and are cascaded to form an 8-bit counter. Both sets of counter chips are inhibited by an output signal from IC9. This signal is an active high and can be connected directly to ICs 15 and 16; 12, 13 and 14, however, require an active low to inhibit them, so an inverter (IC20b) is used to make them compatible.

PB1 is used to reset the address and data counter chips to zero when SW3 is in the WRITE position. SW2c is used to switch the data counter chips (IC15 and IC16) to count up or down.

The outputs from IC15 and IC16 are connected via the tristate buffers IC5 and IC6 on to the RAM input/output bus. This bus carries data from the RAM chips (ICs 1 and 2) to the digital-to-analogue converter (IC3). Therefore, when the circuit is in read mode it has to be buffered from the data counter chips, or the RAM chip outputs will be excessively loaded by the inputs of the data counters. When in write mode the buffers are enabled to allow the data from ICs 15 and 16 to program the RAM.

The output from the data counters and the eight least significant bits from the address counters is fed into the multiplexers IC7 and IC8. SW5 is used to enable the multiplexers to switch between the address and data counters. When SW5 is switched to the 5 volt rail the address counter is connected to comparators IC10 and IC11 and when it is switched to the ground rail the data counter is connected to the comparators.

The comparator chips, IC9, IC10 and IC11, are cascaded to implement a 10-bit comparator which checks the output of the counters with the setting on the programming switches SW6 and SW15. The switches are used to set the maximum length or height of the ramps or steps which make up the waveform.

The length of the ramp is set by comparing the output of the address counter with the limit set by the programming switches. When the switch setting and the output from the counter are equal, IC9 sends out an active high pulse which is used to disable the address and data counters. When the address counter is stopped at the set limit, the data counter is also stopped.

The value at which the data counter stops depends on the slope of the ramp. For example if the limit for the address counter is set to 50 and the slope of the ramp is 4:1, the data counter will stop at 200.

Limits can also be set on the data counter. In this case, both counters are stopped when the data counter reaches its set limit. Ramps can also be programmed this way, but it is used mainly to program the height of vertical steps.

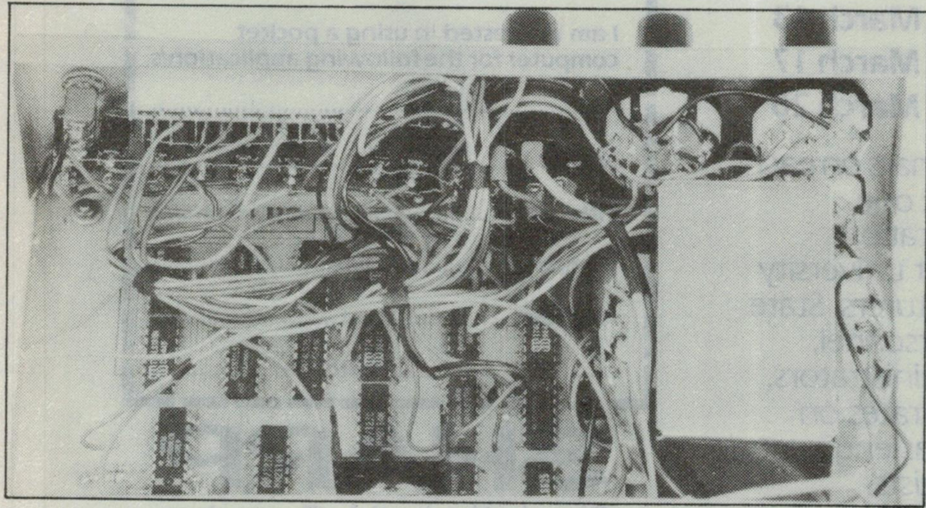
SW16 permits the counters to be manually disabled so that the programming switches can be reset for programming the next slope of the waveform. Without this switch the counters would count from zero each time the programming switches were changed, with the result that the data programmed into the RAM would be overwritten. By disabling the counters manually after they have counted up to the set limit, the next limit can be set. The counters can then continue to count to this new limit when manually enabled via SW16.

address or data bus when the circuit is in write mode. This allows the user to see how much memory has been used and to give a visual display of the programmed waveform. When SW5 is switched from ADDRESS to DATA the user can see the corresponding address and data counter settings; D9 and R7 set the brightness of the display.

The RAM chips, IC1 and IC2 can be programmed with waveforms when SW3 switches an active low to pin 10 of both RAM ICs, also enabling the pins of the tristate buffers (IC5 and IC6). This allows the data input/output pins of the RAM (pins 11 to 14) to receive binary information from the data counters. When SW3 switches active high to the RAM and buffer chips, the input/output pins of the RAM can send binary information to the digital-to-analogue converter.

The analogue section of the circuit consists of a digital-to-analogue converter (IC3) and an op-amp (IC4). The DAC receives the 8-bit digital data from the RAM and converts it into a waveform. The ramps and steps which were described by the counters and stored in RAM as binary data are converted into voltage ramps and steps by IC3 and IC4. IC3 is a current drive device, supplying a differential output signal. The differential output from the DAC is transformed into a single ended voltage drive by IC4, which is a unity gain op-amp. The potentiometer, RV2, provides attenuation of the output signal.

The transformer for the power supply has taps at 30, 24, 15 and 0 volts. The 30 volt output from the transformer is rectified by the diode bridge consisting of D5 and D8 and smoothed by C8 and C9 to give dc levels of +15 and −15 volts. These are regulated by IC22 and IC23 to give +12 volts and −12 volts respectively, providing the voltage rails for the analogue section. To provide a voltage rail for the digital circuitry, an ac output is taken from between the 15 and 24 taps on the transformer. This is rectified by the diode bridge consisting of D1 to D4 and smoothed by C6, to give a 9 volt dc level. IC21 is used to convert this to a 5 volt dc level.



This rear view of the front panel shows the flying leads grouped and taped into clusters. Also note the insulation on the tags of the ON/OFF switch.

can be checked by probing pins 1 and 13 of IC3. This voltage should be within 500 mV of 12 volts. The −12 volt rail can be checked by probing between pin 1 and pin 3 of IC3 and should be within 500 mV of 12 volts. The −12 volt rail can be checked by probing between pin 1 and pin 3 of IC3 and should be within 500 mV of −12 volts. If any of the levels are beyond these limits, switch off the generator and search for short circuits in the vicinity of the voltage rails. Also check that the wiring connecting the components on the front panel is correct.

The output from the generator can now be checked. Make sure the knob labelled AMPLITUDE is turned fully clockwise, the knob labelled COARSE is turned to x1 and the knob labelled FINE is turned fully anticlockwise. Setups 1, 2 and 3 of Table 1 show the conditions for all the switches and the expected voltage levels at the output.

If you get no output at all check that the ▶

PARTS LIST — ETI-171

Resistors................all ¼ watt, carbon film

R1	8k2
R2	6k8
R3, 4	5k6
R5	1k
R6	12k
R7	68R
RV1	100k linear
RV2	10k 240 V switched pot

Capacitors

C1	10n ceramic
C2	68p ceramic
C3	680p caramic
C4	6n8 greencap
C5	68n greencap
C6, 8, 9	1000µ 25 V electro
C7, 10, 11	10µ 25 V tantalum

Semiconductors

D1-D9	1N4004
IC1, 2	2114 RAMs
IC3	DAC800 D/A converter
IC4	741 op-amp
IC5, 6, 17	74LS125 buffers
IC7, 8	74LS257 multiplexers
IC9, 10, 11	74LS85 comparators
IC12, 13, 14	74LS161 4-bit binary counters
IC15, 16	74LS191 4-bit binary counters
IC18	74LS73 dual J-K flipflop
IC19	74LS625 VCO
IC20	74LS04 hex inverter
IC21	7805 5 V regulator
IC22	7812 +12 V regulator
IC23	7912 −12 V regulator

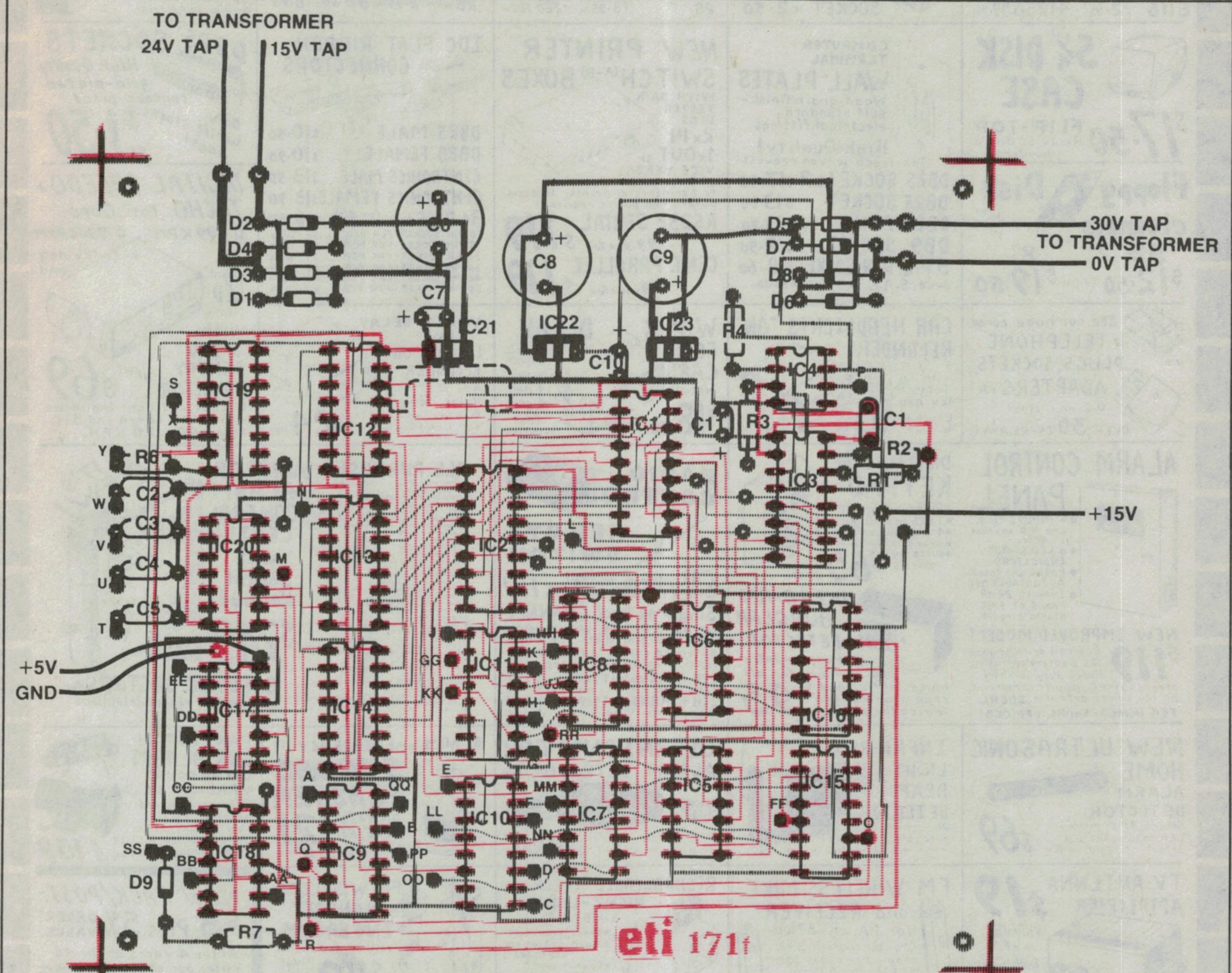
Switches

SW1	2 pole 6 way break before make rotary
SW2	4 pole 3 way rotary
SW3	DPDT toggle
SW4	single pole 4 way rotary
SW5-16	SPDT toggle
PB1	pushbutton

Miscellaneous

ETI-171 pc board; Scotchcal front panel; 30 volt transformer; 5 x potentiometer knobs; RCA jack; 10-segment LED bar graph; case 200 mm x 130 mm x 65 mm; 3 x 4BA nuts, bolts and washers; 4 x 6BA nuts, bolts and washers; 4 x 3 mm spacers; hookup wire; grommet; cable clamp; 240 volt plug and power cord.

Price estimate: $100-$110



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Mono Text card $265
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Hard Disk controller $599
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data and address counters are operating correctly. So that you can troubleshoot the board and to allow better access for probes, it is advisable to remove the nuts holding it in the case and stand it up against the back panel. But be sure to insulate the pc board from the back panel to avoid shorts.

Begin troubleshooting by first checking that the VCO (IC19) is running, using a logic probe to check that the clock signal is coming out of pin 2 (you can use a crystal earpiece or an LED to give an indication of whether a signal is present or not if you do not have a logic probe). If the VCO is running check that the clock signal is getting to pin 2 of IC12 and pin 14 of IC16. If the clock signal is not getting to IC12 and IC16 then the fault lies in the switching network.

If the measured output is not the same as the output level listed in the Table then there is a fault somewhere. To track it down set the ADDRESS/DATA switch to ADDRESS and set the SLOPE knob to 1:4. Also switch the row of programming switches to the 1 state, by flicking them up. Pressing the RESET pushbutton switch, the generator will count through the address and data lines of the RAM. The LED display will be blank when the RESET button is depressed then flicker and light up when it is released.

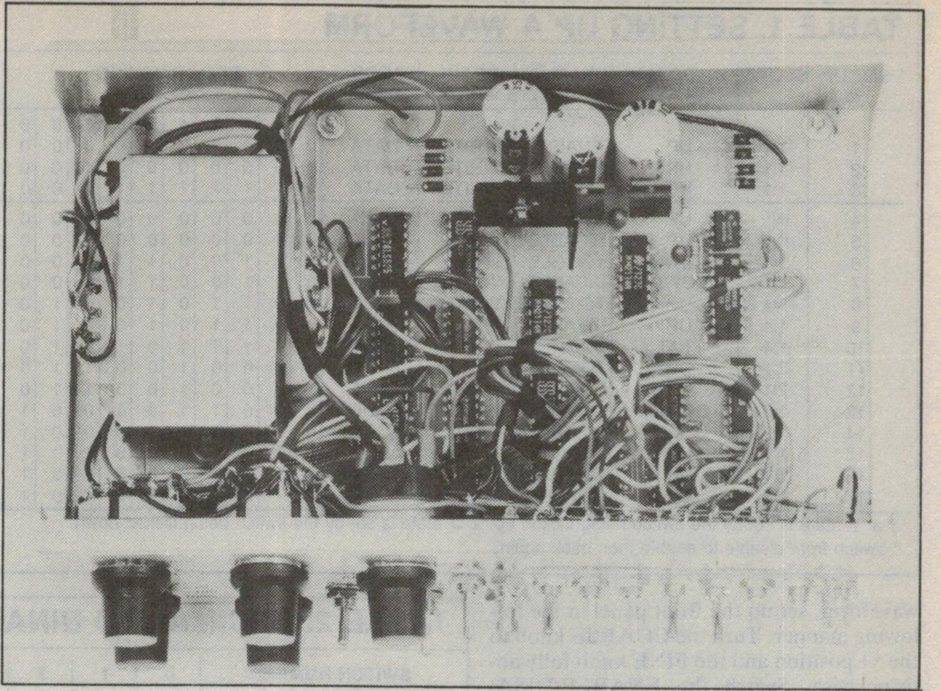
When the RAM has been counted through, the address counter stops and all the LEDs on the display will be lit up. To count through the addresses again, simply depress and release the reset button. Since the ramp slope has been set to 1:4, the data counter will also count through once.

If you do not get any LEDs lighting up on the display, or the display has some segments which are not illuminated, check that the flying leads connecting it to the pc board are fixed correctly. Also check that the flying leads connecting the programming switches to the pc board are connected correctly.

Now that the generator has been set up so that all the address and data lines can be counted through, you can trace these lines for the fault. Remember that the address and data lines are taken to zero when the RESET button is depressed and should output a stream of pulses when it is released. The address and data lines should be left in a high state when they have counted through.

When tracing the fault, check the output from pins 2, 3, 6 and 7 of IC15 and IC16 first, as these are the outputs from the data counter. Then check the output from pins 3, 6, 8 and 11 of IC5 and IC6 as these are the outputs from the tristate buffers. If there is no signal present on any of these lines check for dry solder joints and pads which have not been soldered.

To determine that the address lines are correct check the output from pins 11, 12, 13 and 14 of IC13 and IC14 as well as pins 13 and 14 of IC12.



A view inside the case showing the location of the transformer and the pc board.

If the display continues flickering, check whether pin 6 of IC9 is high. If not then the counters are not being disabled, so look for a fault in the vicinity of ICs 7, 8, 9, 10 and 11. Also check that the programming switches are all connected correctly. If this pin is high check that pins 4 of IC15 and IC16 are high and that pins 7 of IC12, IC13 and IC14 are all low. If this is not the case look for dry joints or unsoldered pins on the abovementioned chips. Also check for faults around pins 10 and 11 of IC20.

If you connect the generator to an amplifier or a high impedance speaker and change the READ/WRITE switch to the READ position the generator should produce a low frequency signal. If not check whether pins 1, 4, 10, and 13 of ICs 5 and 6 are all high. If they're not, check the wires connecting SW3 to the pc board and check the abovementioned pins as well as pin 10 of ICs 1 and 2.

Operation

Before I let you in on creating arbitrary waveforms using the ETI-171 I shall outline the function of all the knobs and switches on the front panel.

In the top left hand corner of the front panel is a knob labelled SLOPE which is used to select the slope of the ramps used in the waveform. The position labelled INF enables a vertical step to be programmed. To the right of the SLOPE knob is a knob used to select whether the ramp goes up or down. The centre position of this knob allows a flat step to be programmed.

The frequency of the output waveform is set by the knobs labelled COARSE and FINE. The latter covers a 10:1 range and the former provides a multiplication factor for this range. The knob labelled AMPLITUDE is the output level control and is also the on/off switch.

The toggle switch labelled ENABLE/DISABLE allows you to put the counters into an inactive state. This is done so that you can change the knobs to make up ramps (namely SLOPE, UP/DOWN/FLAT) and the programming switches without affecting previously programmed ramps. The READ/WRITE switch selects whether the generator is programmed with, or generates a waveform.

The pushbutton switch labelled RESET is used only when the generator is being programmed with a waveform. The function of this switch is to reset the data and address counters to zero so that the waveform has an initial reference point.

The switches labelled 0 to 9 are the programming switches which set in binary the limits for the ramps and steps. Each corresponds to one bit on the address or data counters, therefore all 10 switches are used to set horizontal (address) limits and switches 0 to 7 are used to set the vertical (data) limits.

The switches also have a corresponding LED giving visual indication of the position and displaying the data at a particular address.

The switch in the top right hand corner labelled ADDRESS/DATA enables the programming switches to set limits on either the address or data counters. The ADDRESS position allows you to get the length of ramps and steps on the programming switches. The DATA position is mainly intended for setting the height of steps. It can also be used to set limits for the ramps, but I found it more convenient to set these limits using the address counter.

Before you program the generator with a ▶

TABLE 1. SETTING UP A WAVEFORM

SET UP No	SLOPE	UP/DOWN/ FLAT	ENABLE/ DISABLE	READ/ WRITE	ADDR/ DATA	PROGRAMMING SWITCHES†										DISPLAY										OUTPUT
						0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	
1	1:1	UP	ENABLE	WRITE	DATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	–8.4 V
2	1:1	UP	ENABLE	WRITE	DATA	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0 V
3	1:1	UP	ENABLE	WRITE	DATA	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	0	0	8.3 V
4	INF	UP	TOGGLE*	WRITE	DATA	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	
5	INF	UP	DISABLE	WRITE	ADDR	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
6	1:1	DOWN	TOGGLE	WRITE	ADDR	0	0	1	0	0	1	1	0	0	0	0	0	1	0	0	1	1	0	0	0	
7	1:1	DOWN	DISABLE	WRITE	DATA	0	0	1	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	
8	1:4	UP	TOGGLE	WRITE	ADDR	0	0	1	1	0	1	0	0	1	0	0	0	1	1	0	1	0	0	1	0	
9	1:4	UP	DISABLE	WRITE	DATA	0	0	1	1	0	1	0	0	1	0	0	1	1	1	0	0	1	0	1	0	
10	1:4	FLAT	TOGGLE	WRITE	ADDR	0	1	1	1	1	0	1	0	1	0	0	1	1	1	1	0	1	0	1	0	
11	2:1	UP	TOGGLE	WRITE	ADDR	0	0	0	0	1	0	0	1	1	0	0	0	0	0	1	0	0	1	1	0	
12	2:1	UP	DISABLE	WRITE	DATA	0	0	0	0	1	0	0	1	1	0	1	0	0	0	1	1	0	1	1	0	
13	1:2	DOWN	TOGGLE	WRITE	ADDR	0	0	0	1	1	0	1	0	0	1	0	0	0	1	1	0	1	0	0	1	
14	1:2	DOWN	DISABLE	WRITE	DATA	0	0	0	1	1	0	1	0	0	1	0	1	1	1	0	0	1	0	0	1	
15	1:1	UP	TOGGLE	WRITE	ADDR	0	1	0	1	0	0	0	1	0	1	0	1	0	1	0	0	0	1	0	1	
16	1:1	UP	DISABLE	WRITE	DATA	0	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	
17	1:1	UP	ENABLE	READ	ADDR	0	1	0	1	0	0	0	1	0	1											

† a '1' state is set by the switch being flicked up; a '0' state is set by the switch being flicked down.
* switch from disable to enable then back again.

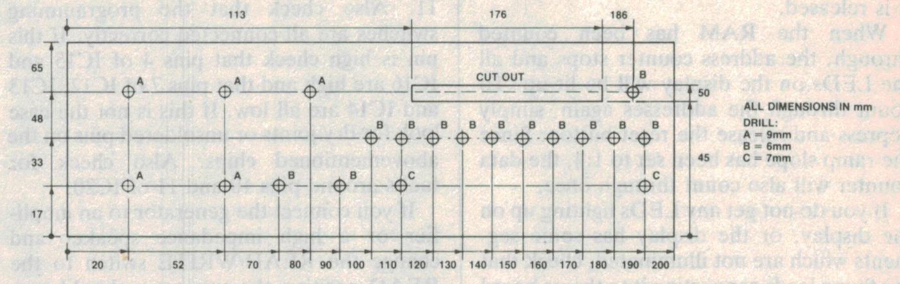
waveform, set up the front panel in the following manner. Turn the COARSE knob to the x1 position and the FINE knob fully anticlockwise. Switch the ENABLE/DISABLE switch to the DISABLE position, the READ/WRITE switch to the WRITE position and the ADDRESS/DATA switch to the ADDRESS POSITION. Press the RESET button and the display should clear and the generator is ready to be programmed with a waveform.

The limits for the ramps which make up the waveform are set in binary form by the programming switches with the least significant bit on the left hand side of the panel (labelled 0). The most significant bit for the address counter is on the extreme right of the panel (labelled 9) and the most significant bit for the data counter is labelled 7. Since there are 10 switches to set the address value, 1024 steps can be utilised horizontally. The eight switches which are used to set the data value allow 256 steps to be used vertically. To enable you to convert from binary to decimal look at Table 2. When one of the switches is flicked up that number of steps is counted. For instance, if only switch 5 is flicked up, 32 steps are counted and if only switch 6 is flicked up, 64 steps are counted. To allow intermediate steps to be programmed combinations of these steps can be switched in. Some combinations are also listed in Table 2 to show how these intermediate values can be achieved.

When you are creating ramps, using the programming switches and the SLOPE and UP/DOWN/FLAT switches flick the ENABLE/DISABLE switch to the DISABLE position. Once these switches have been set flick the switch to the ENABLE position to put the ramp you have described into the RAM. The LED display will be lit up with the setting on the programming switches to show that the limit has been reached. Now flick the ENABLE/DISABLE switch to the DISABLE position because the limits and slopes can only be set when it is in this position.

TABLE 2. DECIMAL TO BINARY VALUES

SWITCH NUMBER	0	1	2	3	4	5	6	7	8	9
No OF STEPS	1	2	4	8	16	32	64	128	256	512
50	0	1	0	0	1	1	0	0	0	0
100	0	0	1	0	0	1	1	0	0	0
150	0	1	1	0	1	0	0	1	0	0
200	0	0	0	1	0	0	1	1	0	0
DECIMAL VALUE	BINARY VALUE									



The LED display can also show how many steps of data have been used by flicking the ADDRESS/DATA switch to the DATA position when the generator is in DISABLE mode. This is useful in preventing the data lines of the RAM from being cycled by preventing the data counter from exceeding 256 (256 is indicated by the illumination of numbers 0 to 7 on the display).

The waveform in Figure 2 can be programmed in the following manner. The initial data point is a step of 128, and is set as described by setting no 4 in Table 1. This sets the starting point of the waveform to zero volts. Now set the panel as described in setting no 5 and the display should be blank. The parameters for the first ramp can then be set using setting no 6. Setting no 7 shows the data value at the end of the first ramp. Setting no 8 puts in the second ramp and setting no 9 shows the expected display. Only take notice of display segments 0 to 7 as these are the only ones relevant to the display of data. Also the value of this point may vary by up to three steps due to division of the clock signals used to derive ramps which are not 1:1. Ramps with a slope of 1:1 may be out by 1 step, which is due to the clocking of the counters generating the ramps.

Setting no 10 puts in the flat region between addresses 300 and 350. Setting no 11 puts the steep ramp and setting no 12 shows the data value at this point. Setting no 13 puts in the negative going slope and setting no 14 shows the data value at the end of the ramp. Setting no 15 makes the start and end data value of the waveform the same, to allow a periodic waveform without glitching. Setting no 16 checks the data value at this point.

To get this waveform out of the generator set up the front panel as shown in setting no 17, making sure that you flick the ENABLE/DISABLE switch last of all to prevent you inadvertently re-writing some of the waveform. ●

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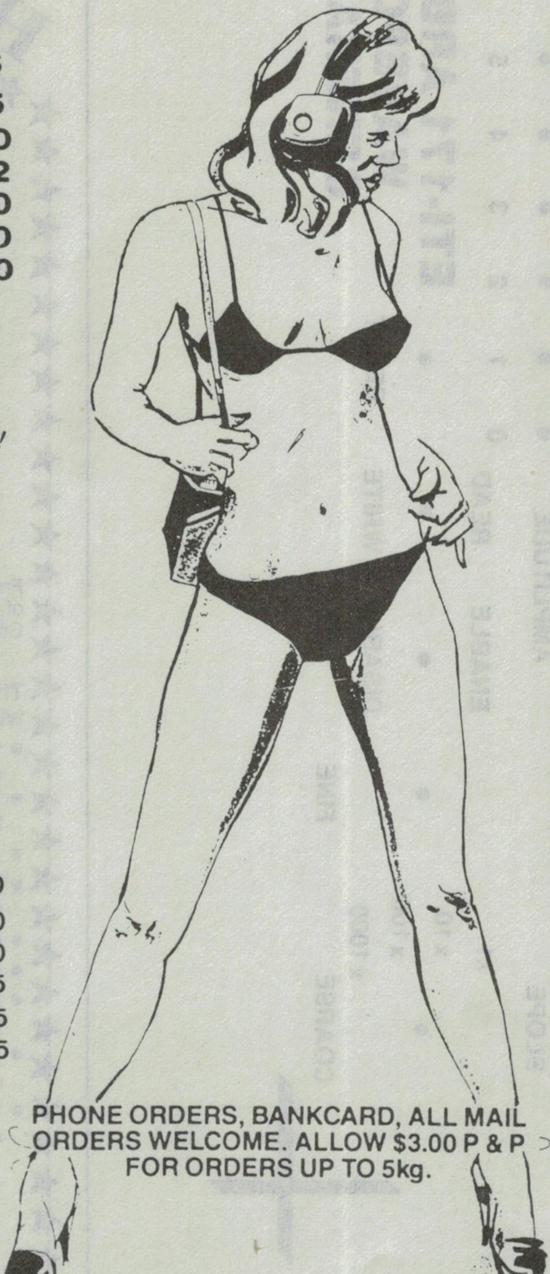

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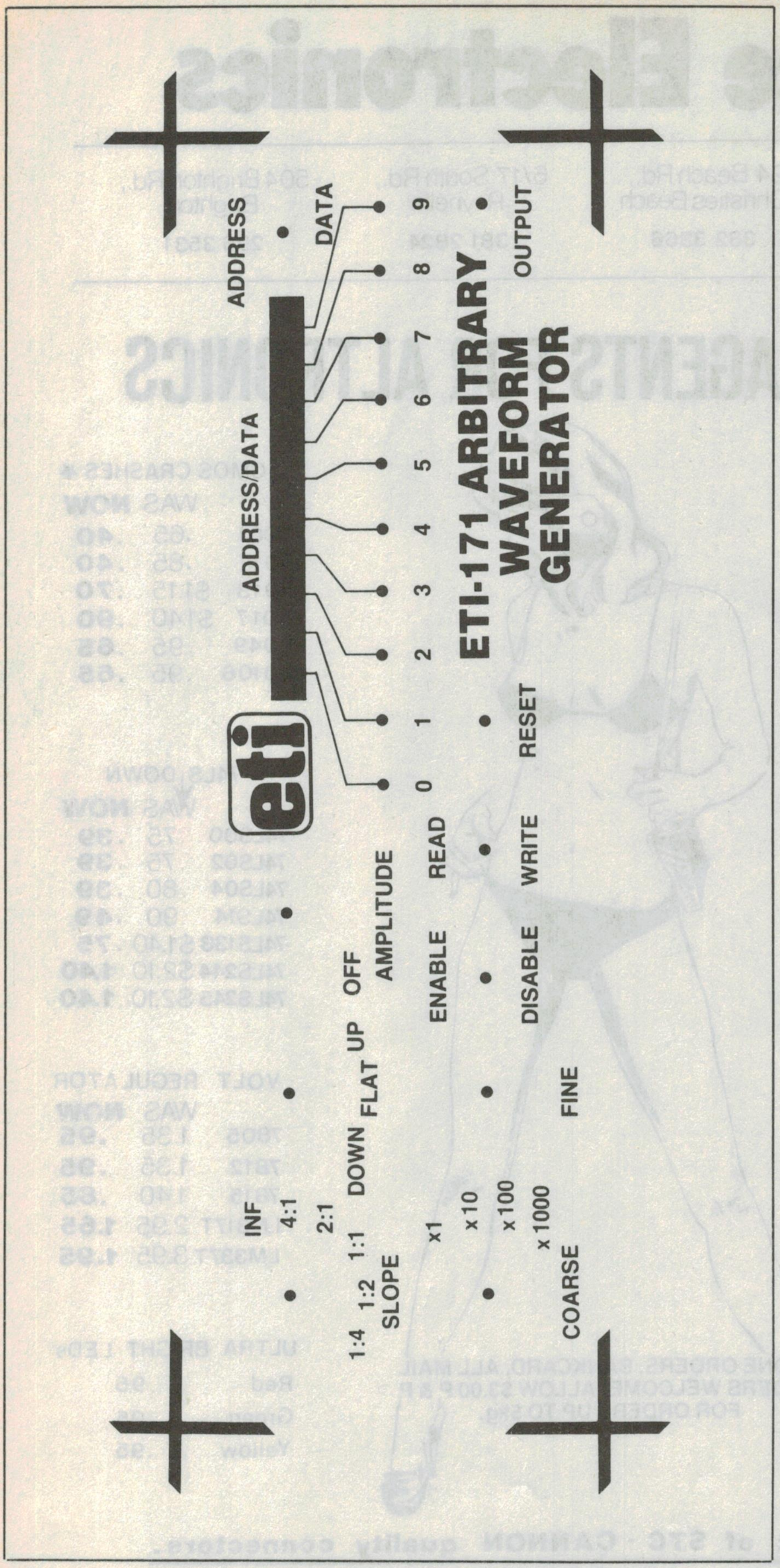
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ADDRESS/DATA
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WRITE
ENABLE
DISABLE
AMPLITUDE
OFF
UP
FLAT
DOWN
INF
4:1
2:1
1:1
1:2
1:4
SLOPE
x1
x10
x100
x 1000
COARSE
FINE

INTELLIGENT MODEM

In the December issue of ETI we described the workings of modems generally and the considerations of this 1200/75 modem in particular. Part 2 gets down to brass tacks and tackles the modem's auto dialling function.

Part 2

S.K. Hui

I SUPPOSE ANY five-year-old kid knows how to make a phone call. Very simple mechanical movements like picking up the handset, dialling the numbers one by one and listening for tone are all that's required. All of us have adopted such mechanical habits without so much as a second thought about how they work. Since automatic service tones detection and dialling are some of the standard features available in the ETI modem, this article will introduce you to some of the techniques used in our modem to perform these boring, repetitive dialling tasks which would otherwise have to be carried out manually.

Whether you are waiting anxiously to build and use our modem or are just generally interested in Telecom interfacing, the next sections will help you to understand the whole business. In fact, even if you are in the area of alarm systems, automatic answering machine manufacturing etc, you will find this article valuable. But herewith the warning: you *must* get Telecom permission before you connect to the line. My job here is simply to explain the principles.

Line interfacing hardware

A typical hardware setup for line interfacing is shown in Figure 1. All the relays drawn are in their de-energised positions. The first relay, RLY1, is used to control the Telecom line. In its normally off position, the line is connected to the telephone, allowing your phone to be used as usual. Energising RLY1 simply disconnects the phone from the line. The second relay, RLY2, in its normally off position, as shown in the Figure, connects the line to the bell detecting circuit. Your phone rings whenever an ac signal of about 25 Hz and 50 volts rms is sent down from the exchange. This ac signal, which I will refer to as the bell signal, triggers the bell detector circuit. The detector is designed around the 10 kV optical isolator. There are two complementary electrical paths in the bell detector, one formed by diodes D1 and D2 and the other formed by D3 and the LED which is built into the isolator.

During the one half cycle of the bell signal, depending on whether point A is at a higher or lower voltage potential than point B, one of the two paths will turn on and allow the signal to get through. In the next half cycle, the roles of the two paths will reverse. In the presence of the bell signal, point A will be more positive than point B half of the time and turn on D3 and the LED. As a result, pulses appear at the emitter of the transistor, Q1, when the phone rings. The pulses are already in TTL level and can be directly interfaced with an I/O port. When the phone rings the microprocessor in the modem detects it and gets ready to react to various possible situations (as explained in Part 1).

Energising the relays, RLY2 and RLY4, disconnects the bell detecting circuit and ▶

connects the line transformer in parallel with the phone (providing RLY1 is off). If the phone is in use when this occurs the transformer will seize some of the audio signal of the line. Naturally, there will be a drop in the volume level of the phone, which is pretty annoying for anyone who is using the phone; therefore, the configuration of RLY1 off, RLY2 and RLY4 on is normally forbidden. The exception is when the microprocessor in the modem wants to find out whether the phone is in use before it starts a dialling sequence. A few seconds is all the micro needs to determine the line condition. Of course, most of the time, the operator giving the dialling command to the modem sits near the phone and knows whether it is in use or not!

A second safety check is built into the software to make absolutely sure that the phone is free before dialling. Having RLY1 off and RLY2 and RLY4 on merely connects the line to the transformer, which is not sufficient to enable the software to detect conversations on the line. What finally does the trick is an extremely simple circuit predicted by Murphy's Law — "simple circuits are usually hass free".

An op-amp connected to the secondary winding of the transformer amplifies the voice signal. Output of the op-amp is squared up by the following transistor switch which, in turn, triggers a monostable. With the help of this simple 'Murphy's circuit', the micro only has to examine the output of the monostable to know whether there is any signal on the line. The monostable is a typical re-triggerable type with about a 25 ms timing constant. The significance of the monostable will become apparent in the later sections of this article.

Relays, RLY3 and RLY4, are used only during the dialling process. RLY4 is an ultra low inertia reed relay specially selected for the dialling purpose. A low pass network formed by R and C is required in shunt with RLY4 to quench the sparks generated by the fast opening and closing of RLY4 during the dialling.

Automatic dialling

Let's start at the point where the operator supplies a phone number for the modem to dial. Using the Hayes dial command (see Part 1), it looks like

```
ATDO,1234567 [return]
```

Upon reception of the ASCII code, the micro in the modem first checks the argument of the command to make sure it consists only of digits.

The comma , is to indicate to the micro that an internal PABX phone is connected to the modem. After dialling out the first digit 0, the control program in the micro rechecks the presence of dial tone before dialling the telephone number. If no dial tone is detected within three seconds the remaining digits will be ignored and a warning message sent back to the operator.

The best way to see such a control work in the program is by following a flow chart. If the command and argument supplied by the operator are correct, the micro will loop the line by turning RLY2 and RLY4 on.

The phone will be either idle or in use. In the former situation, looping the line will cause the exchange to send down the dial tone. The carrier frequency of the dial tone is 425 Hz modulated by 25 Hz tone. The 425 Hz carrier has a period of about 2.35 ms; this is amplified and continuously re-triggers the monostable set with a 50 ms timing period so it's always high.

If the phone is in use the output of the monostable is sometimes high and sometimes low, corresponding to normal conversation on the line. The timing period in the monostable is specially chosen to be short (50 ms). The silence gap between each word we say is long enough for the monostable to time out and become inactive (low).

Thus the output of the monostable allows the micro to distinguish the two different conditions.

A third condition where the monostable output will respond with a constant low arises if the modem is not plugged into the line socket or there is a fault somewhere down the line.

If the line is free to be used by the modem, the rest of the process is a lot simpler. RLY3 is turned on to short circuit, that is, *makes* the line. The software loads the first digit to be dialled into accumulator A. The system is then ready to dial the telephone number. RLY4 is turned off to open circuit, that is, *breaks* the line for 66 ms, followed by 33 ms of making the line. This is one dial pulse only; a digit, say 5, would require that same make-break sequence five times. Before the next digit is dialled, an 800 ms inter-digital pause is generated. The same sequence carries on until all the digits have been dialled.

Relay RLY3 is then turned off, but RLY4 and RLY2 are left on to allow the 600 ohm transformer coil to connect to the line for audio communications. A small piezoelectric earpiece connected to the secondary coil of the transformer would allow you to hear the service tone back from the line. In the actual modem, a loudspeaker is installed and can be turned on or off through the keyboard using the standard Hayes command, enabling the operator to listen to what's happening on the line with a touch of his keyboard.

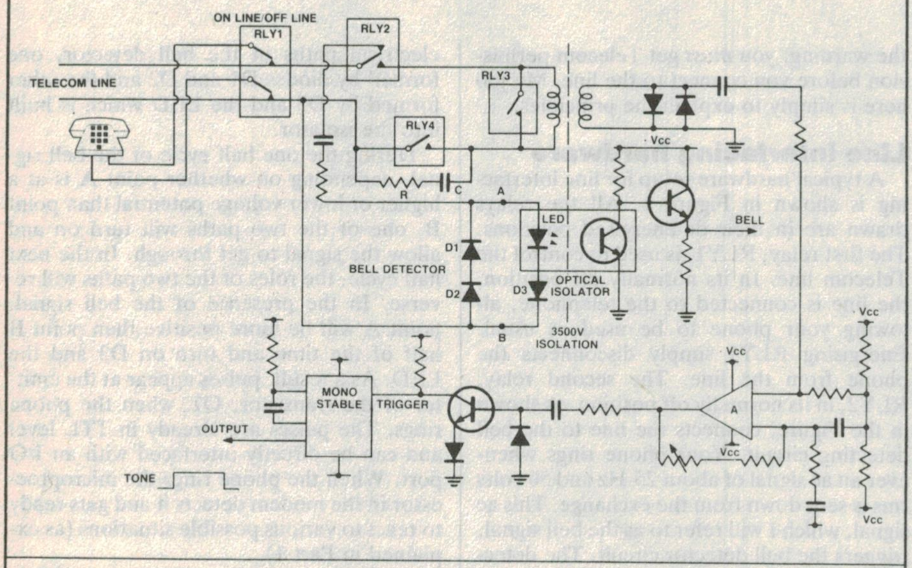


Figure 1. Hardware line interface.

Automatic service tone detection

The same monostable and hardware setup is also used to detect different tones on the line — at minimum cost. Most of the common tones like dial, busy, ring etc, use the same carrier and modulating signals. The only difference between them is the cadence or, if you like, the on/off cycle of the tone. Busy tone has a 0.375 s on and 0.375 s off cadence while ring tone is 0.4 s on, 0.2 s off, 0.4 s on and 2 off before the sequence repeats.

When the tone is on, the output of the op-amp (see Figure 1) is amplified, and triggers the transistor switch. So when the tone is on, the output signal on the transistor switch is not constantly on, but pulsating as shown in Figure 2. The pulsation rate is

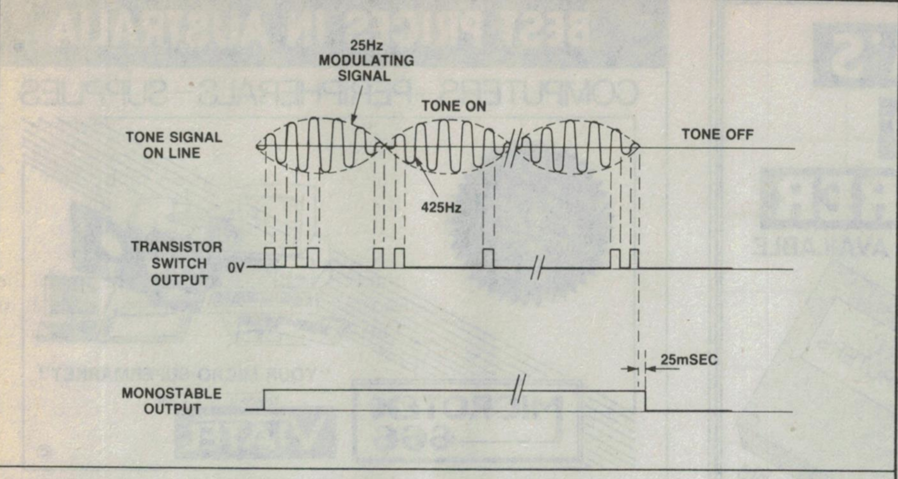


Figure 2. Timing waveforms of the service tone detection circuit.

about the same as the carrier frequency in the tone, that is, 425 Hz.

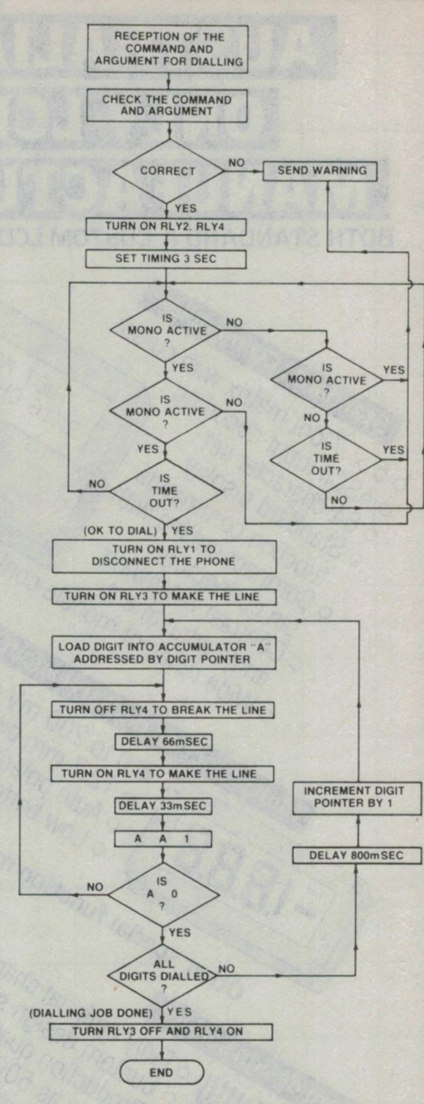
This is not what we want at all. Rather, we want an active high signal for as long as the tone is on and a low signal when it's not. This accounts for the re-triggerable monostable tuned to a timing constant of about 25 ms. The pulses are sent from the transistor switch with a 2.35 ms repetition rate refreshing the timing cycle of the monostable before the 25 ms is timed out. It is that 2.35 msec which sets the lowest limit we can choose for the timing cycle of the monostable. The upper limit is, of course, set by human response, that is, the normal gap of silence between our words.

Since the pulses keep triggering the monostable, an active high signal on the output of the monostable is achieved when the tone is present. This makes it possible to implement tone detection in the software. The software first allocates two blank memory locations (registers) for counting. Either one of the two blank registers is incremented by one every time the control returns from the monostable scanning trip, depending whether the output of the monostable is high or low. The control returns to scan the monostable output again. This process keeps up till the end of the three seconds acquisition period. The final values stored in the two registers will be different depending on whether it was a busy or a ring tone. The exact value varies from call to call and from exchange to exchange. The software needs to know which number is greater in order to determine what tone is on the line.

One would hope for one number always greater than the other, but real life always turns out to be a little more complicated. Table 1 shows some of the data I acquired using this scheme. *Count-I* and *bcon-bctr* are names of the two registers discussed above. *Count-I* gets incremented if the scanning of the monostable shows that it is active, otherwise, *bcon-bctr* is incremented. As shown in the Table, the values (all in hexadecimal) recorded in *Count-I* are always smaller than *bcon-bctr* if ring tone is received but greater if the tone is busy. Fine! But this is only between calls made on an internal PABX system. When it comes to direct line to direct line (as when you call up your friend from your phone at home), it is a completely different story. *Count-I* is always smaller than *bcon-bctr* no matter what. The situation is further complicated by the requirement that the software detect whether nothing is connected to the line at the other end, or if someone picks up the phone at the other end before the acquisition period is finished.

Fortunately, the solution to the problem is surprisingly simple. The figures shown in Table 1 were acquired with the data acquisition program starting 66 ms after the last dial pulse. The same delay time is used in both PABX and direct calls. If the delay time is extended to 2 seconds for a direct call, we achieve the condition we want. Now the value recorded in *Count-I* is greater when the line is busy. Table 1a-c displays some of the values I obtained using different delay times (66 ms and 2 seconds) for PABX and direct calls.

The extended delay time to 2 seconds for a direct call does not in any way degrade the performance of the modem. You must be aware of the fairly long wait for the exchange to connect you after you have dialled the last digit. I actually timed it to about 2 seconds before tone appears. So, most of the data acquisition is carried out even before the called phone starts to ring. While it seems that the ringing tone you hear from the receiver coincides with the phone ringing at the other end, in actual fact, the two signals are not necessarily coincidental. Most of the time, the ring tone starts earlier in your receiver than the bell rings in the called telephone. This time delay between the ring tone and the bell signal allows the acquisition program to nearly finish even before the other end starts to ring. Table 1d shows the data acquired in *Count-I* and *bcon-bctr* when the phone is answered as soon as it starts to ring. It shows that *Count-I* is still greater than *bcon-bctr* and recognised by the software as ring tone. The software is designed to compare the values in the two registers but not their



Auto dialling flowchart.

absolute values. So how quickly one picks up the phone doesn't affect the correct decision of the software.

However, there is an exception in the case that nothing is connected to the line at the other end. In this case the line will be almost silent and the number recorded in *Count-I* will be very small as shown in Table 1e. This condition is easily detected by first comparing the value in *Count-I* with a fixed number such as $001000. The software only proceeds to differentiate between busy or ring tone if *Count-I* is greater than $001000.

Off-hook detection

If the software concludes the tone is busy, it will turn off RLY2 for 1 or 2 seconds (on-hook the phone) and repeat the whole dialling process. If ring tone is detected, the program jumps to a different routine to detect when the called phone is picked up (off-hooked). Again, exactly the same circuit is used as for tone detection in order to reduce cost.

The design strategy for this part of the software is based on the fact that the longest ▶

gap in the ring tone is 2 seconds, plus a bit for tolerance and fluctuations in different exchanges. The software scans the monostable output and increments a register everytime it is found to be inactive. Before the control returns to scan the monostable, the value in the register is compared to a fixed number carefully selected to correspond to about 2.5 seconds. If the register value is smaller, the scan-compare sequence resumes. If bigger, it indicates that the silent period is longer than 2 seconds and the called phone is off-hooked.

So, what happens if the person answering the phone makes a lot of noise? Well, the monostable will be triggered and continuously active. Another register will be incremented to eventually become greater than the fixed number. I asked many people to pick up the phone and answer it in the normal manner. The silent gap between their "hello" or "hi" or "who's calling" etc, was long enough to allow the software to find out that the called phone was off-hooked. The response time of the system is about 2.5 seconds. That is, it takes 2.5 seconds to find out that you have off-hooked the phone, and the calling modem will send out a calling tone, expecting the answering tone back from the other end for normal data communications.

There is one rather unlikely situation which might occur and should be accounted for. What if the answering phone is picked up and immediately hung up? The exchange sends the busy tone down the line and the alternate on/off of the tone will keep the software waiting for the other end to off-hook. Remember that the off-hook detection software will look for a long (2.5 s) silence period. To overcome this trap, everytime this routine is about to be executed, the software triggers a hardware timer for about 1.5 minutes. If the tone, either ringing or busy continues longer than that, the hardware timer times out and the software control quits the routine. Otherwise, the control will be trapped in an infinite loop●

TABLE 1. DATA ACQUISITION IN THE TWO CONTROL REGISTERS

a) NORMAL ACQUISITION TIME (3 s)
PABX — INTERNAL TO INTERNAL: delay time 66 ms

	RING TONE		BUSY TONE	
Telephone	Count-I	bcon-bctr	Count-I	bcon-bctr
1	100E1D1	$01CC8B	$01F81F	$00B11E
2	$007076	$023395	$0200A2	$00B3A5
3	$0070C6	$02337A	$02013E	$00B097
4	$00E151	$01D122	$01ED99	$00C1A6
5	$00E0EF	$01D53D	$0202CA	$00B0C6
6	$007601	$0233A8	$01FFE4	$00B094
7	$0070A1	$02336F	$01FC52	$00B03B
8	$007659	$02335D	$0200C1	$00B3C9
9	$0076AC	$023360	$020044	$00B7FD

b) NORMAL ACQUISITION TIME (3 s)
DIRECT TO DIRECT: delay time 66 ms

	RING TONE		BUSY TONE	
Telephone	Count-I	bcon-bctr	Count-I	bcon-bctr
1	$0081AA	$02118A	$00FA43	$019D07
2	$007EED	$02065C	$012D70	$016CA9
3	$00A084	$0200D3	$00EB84	$01AE80
4	$01034C	$019F20	$00F03E	$01B9DB
5	$00D3A8	$01D4B9	$01104E	$017248

c) NORMAL ACQUISITION TIME
DIRECT TO DIRECT: delay time 2 s

	RING TONE		BUSY TONE	
Telephone	Count-I	bcon-bctr	Count-I	bcon-bctr
1	$0050E5	$01156A	$011760	$0055D9
2	$005CC2	$010A84	$011500	$0055E0
3	$007EA6	$010826	$010EAB	$0056AC
4	$006222	$011A58	$0110A0	$0055E2
5	$005EE6	$011532	$011120	$0055FF

d) INTERRUPTED ACQUISITION TIME*
PABX: internal delay 66 ms; DIRECT: delay 2 s

	RING TONE	
Telephone	Count-I	bcon-bctr
1	$007F86	$00D6AC
2	$006B1A	$00E773
3	$007020	$00DEFA

* ie, called phone is answered as soon as ring begins

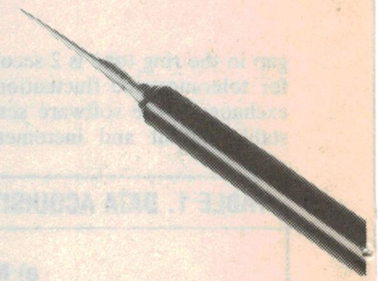
e) NOTHING CONNECTED TO LINE

Telephone	Count-I	bcon-bctr
1	$00-0000	$0160D5
2	$002232	$0149D8
3	$000120	$015FB5

BE CAREFUL

Kit constructors who habitually browse through the magazines on the news stand in search of good projects will no doubt be aware that modem circuits are as common as mud. We strongly urge you to be careful in your choice of modem kits to build. There are some points to watch. NEVER build a modem that contains 240 Vac on the same board as line circuitry. This is so horrendously dangerous, both for you and for any poor Telecom tech sitting in the exchange, that perpetrators of such circuits ought to be run out of town on a rail. Try to ensure that any modem you buy meets all Telecom specs for safety and performance. Whatever its faults, Telecom does know about Telecommunications, and its safety advice ought to be taken seriously.

Another point: the Viatel standard split baud rate 1200/75 is very popular, but make sure the modem you buy does not talk to its host terminal at the same speed. Terminals that talk to their modems at 1200/75 are few and far between, and DO NOT include most of the popular micros unless you get a special terminal package. Be suspicious of all single chip modems.



VIBRATION DETECTOR

To assist in determining the source of annoying vibrations in mechanical equipment and structures here is a low cost vibration detector for you to build.

Neale Hancock

THE BEACH BOYS may have written songs about Good Vibrations in the '60s, filling us with the idealism of those heady days, but not all vibrations have such a positive effect on us and our material possessions.

Vibrations in cars and other mechanical and structural entities are not only annoying but are also potentially dangerous. They're sometimes tricky little things to find and isolate, as the car mechanic would probably testify.

The applications for a fairly sensitive vibration detector are more numerous than you might first think. Under the bonnet, for example, you can save the screw driver for screwing and take up a vibration detector to sense the origin of an elusive rattle. One more specialised use suggested in this office was in assisting the plumber tracing water pipes; you can see how the vibration detector could come into its own in a much wider field.

To allow vibrations to be detected in places where there is not much space, this project uses a probe to transmit mechanical vibrations to a transducer. The probe must be long enough to reach into tight corners, but without a large inertial mass. If the probe had a large inertial mass, low level and high frequency vibrations would be more difficult to detect.

To achieve both of these criteria a multimeter probe was used in preference to a metal probe. As the multimeter probe has a steel tip and a rigid plastic body it is ideal for picking up vibrations from a surface to carry them to the transducer. Another benefit of the probe having a plastic body, is that it electrically insulates the vibration detector from the surface being probed. Therefore the chances of receiving an electric shock from accidently probing a live electric wire are reduced.

The transducer (which converts mechanical vibrations into electrical signals) consists of a probe directly connected to an electret microphone. For the microphone to pick up vibrational signals only it is sealed from the air so that its diaphragm is only moved by the mechanical vibrations transmitted by the probe. By sealing the microphone from the air, detection of ambient sounds is also prevented.

Since the signals from the transducer are low in level (between 100 microvolts and 2 millivolts) a high gain op-amp is used to amplify them to hearing level. The gain of the op-amp can be varied from 100 to 2000 so that vibrations of different levels can be detected undistorted.

Construction

Commence the construction of this device by assembling the printed circuit board. Firstly solder in the three capacitors, making sure that they are orientated correctly. Next the resistors go in followed by the integrated circuit, making sure that pin 1 of the IC is orientated towards capacitor, C1.

To enable the electret microphone to operate as a vibration transducer it must be connected to a probe and sealed from ambient sound. To connect the probe to the microphone, a short bolt (about 6 mm in length) is screwed into the hollow barrel of the probe. The bolt's head should be about 8 mm in diameter so that it can cover the opening of the microphone's cavity.

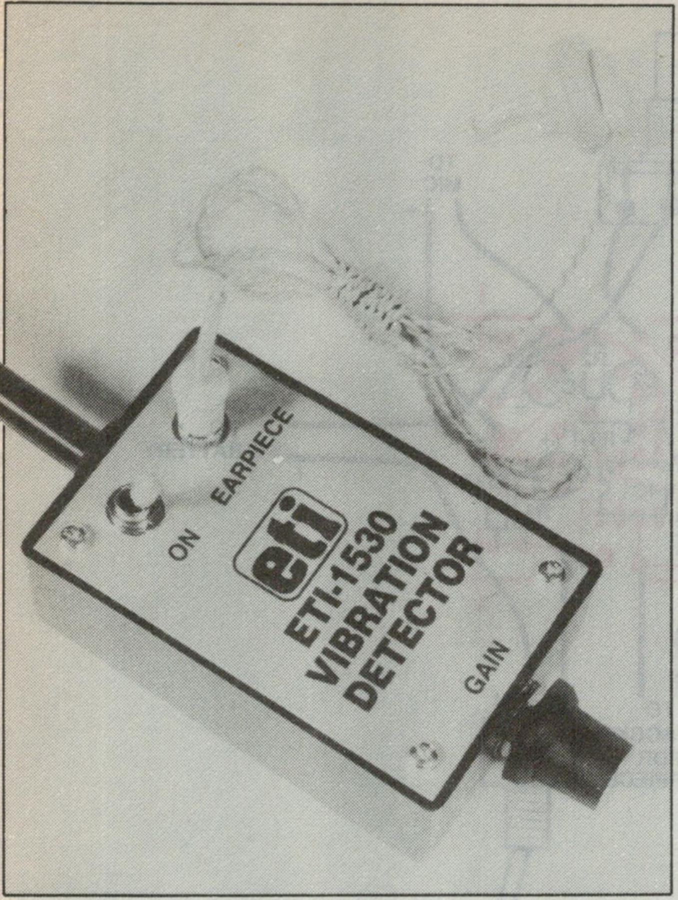
Remove the felt dust cap from the microphone and use a fast drying glue to mount it on the bolt. The bolt's head should be mounted over the microphone's opening and glued around its rim. Take care not to allow any glue to flow inside the microphone as it would restrict the motion of the diaphragm and thus reduce the effectiveness of the microphone as a transducer. By glueing around the rim of the bolt head, the microphone cavity is sealed from ambient noise. After the glue has set you may wish to use some silicone sealant to make extra sure of an airtight seal.

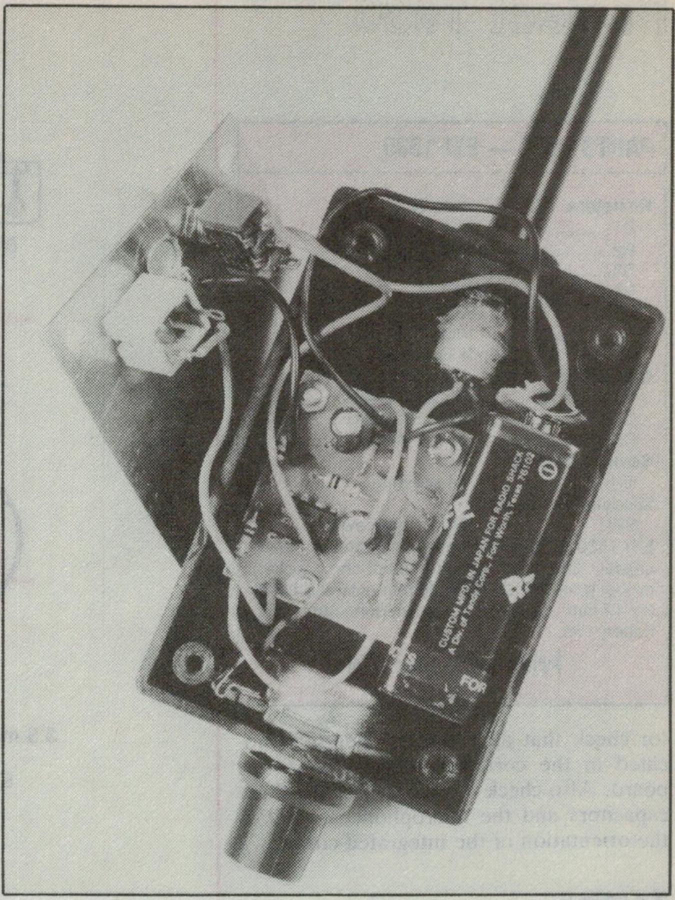
Before the probe is mounted, a rubber grommet is installed in the 10 mm hole at one end of the case. This not only allows the probe to fit tightly into the case but it also prevents the case from absorbing vibrations from the probe. The probe is mounted by pushing it through the grommet from the inside of the case. Now link the probe to the pc board as shown on the overlay; be sure to check the polarity of the microphone first. The ground terminal can be easily identified as it is linked to the body of the microphone. The leads should be kept short to reduce noise pickup.

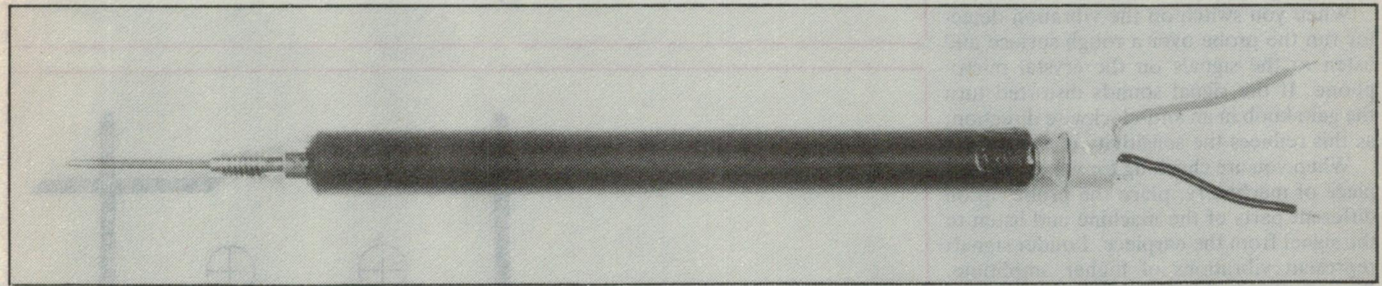
The leads connecting the variable resistor to the pc board can now be soldered in, as shown on the overlay diagram. When the variable resistor is mounted be sure to orientate the solder lugs towards the left wall of the case (with pot shaft facing you) to prevent them shorting on to the metal lid.

Next connect the earphone socket, the battery clip and the switch to the pc board with flying leads. Bolt the pc board into the case using 6BA 20 mm bolts; use 12 mm spacers to give the pc board some clearance from the bottom of the case. The battery can now be mounted and should fit tightly between the pc board and the wall of the case. Finally the earphone socket and the switch can be mounted on the metal lid of the case.

Before you switch on the vibration detec- ▶



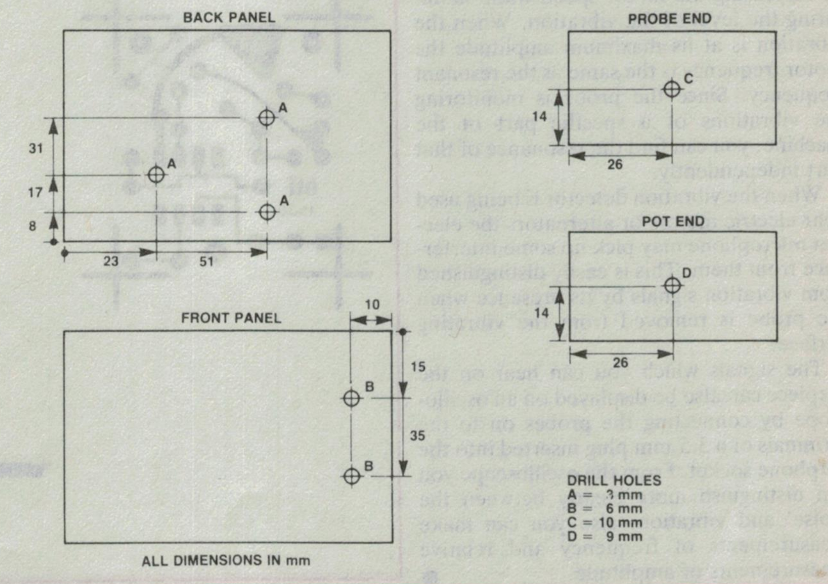




Top right: An internal view of the vibration detector showing how the battery, pc board and probe are mounted.

Above: An assembled vibration probe showing the mounting of the microphone on the barrel of the multimeter probe.

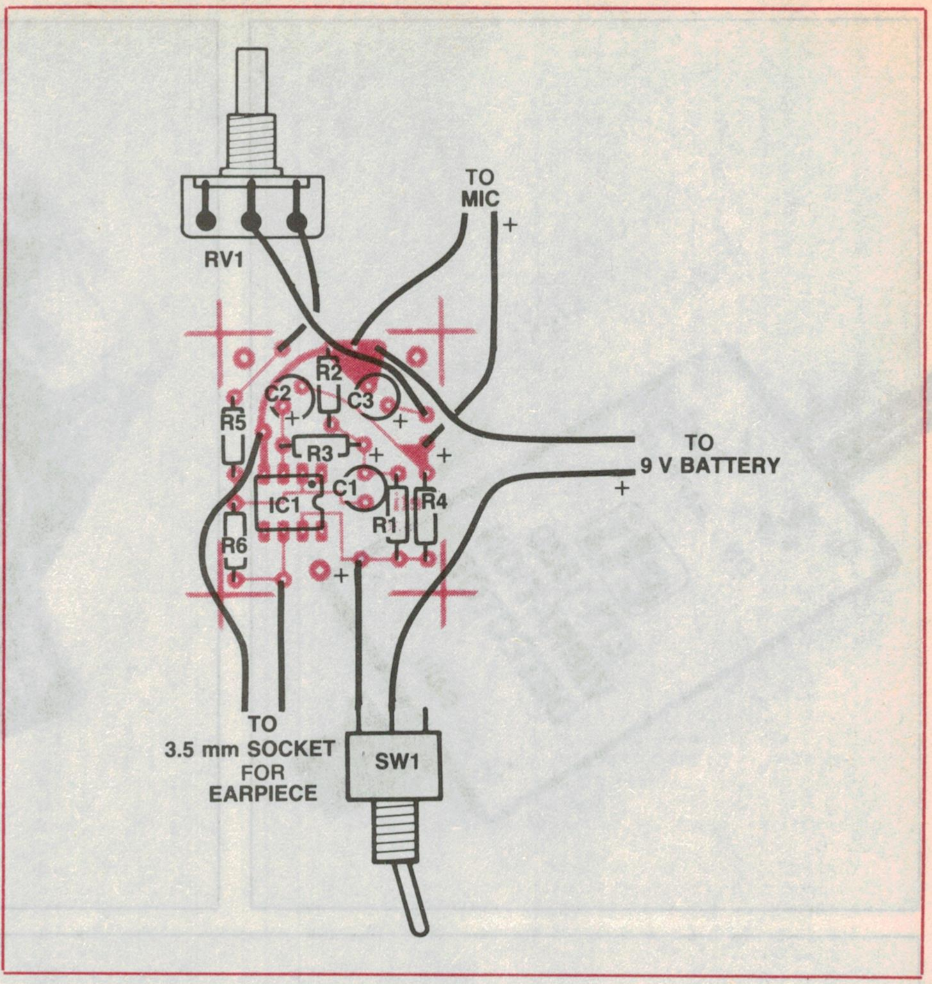
Below: A rear view of the electret microphone. Note that the negative terminal is linked to the tape.



PARTS LIST — ETI-1530	
Resistors	all ¼ W, 5%
R1	82k
R2	120k
R3	10k
R4	4k7
R5	68R
R6	100k
RV1	1k linear pot.
Capacitors	
C1	47µ 25 V electro
C2	1µ 25 V electro
C3	10µ 25 V electro
Semiconductors	
IC1	741 op-amp
Miscellaneous	
SW1	SPDT toggle switch

ETI-1530 pc board; electret microphone insert; crystal earpiece; 3.5 mm earphone socket; probe; grommet; 3 x 6BA 20 mm nuts and bolts; 3 x 12 mm spacers; small broadheaded bolt; battery clip.

Price estimate: $19



tor check that all the components are located in the correct positions on the pc board. Also check the polarity of the three capacitors and the microphone as well as the orientation of the integrated circuit.

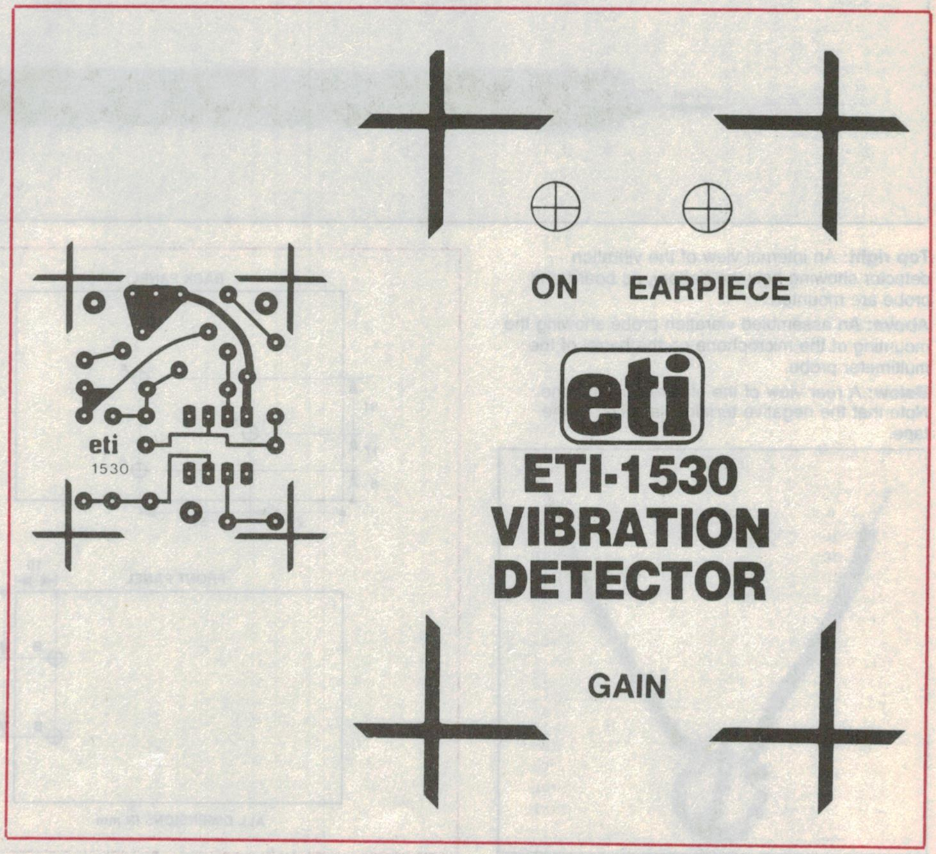
Testing

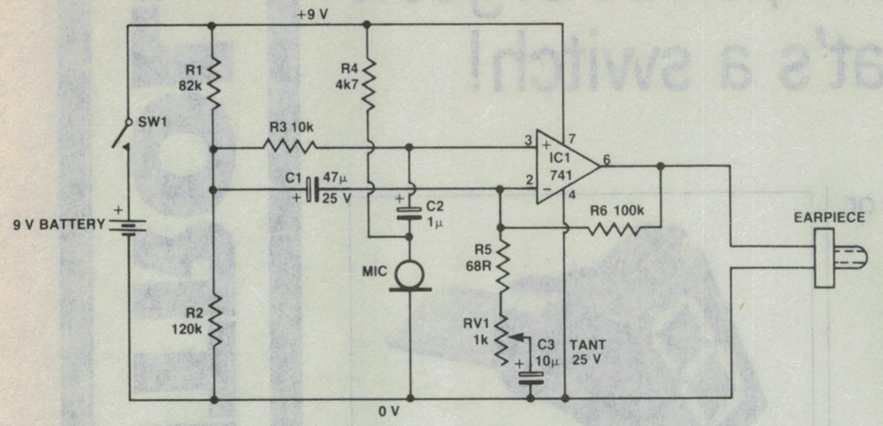
When you switch on the vibration detector run the probe over a rough surface and listen to the signals on the crystal microphone. If the signal sounds distorted turn the gain knob in an anti-clockwise direction, as this reduces the sensitivity of the unit.

When you are checking for vibrations in a piece of machinery, place the probe tip on different parts of the machine and listen to the signal from the earpiece. Louder signals represent vibrations of higher amplitude. Resonances can be detected in this manner by increasing the motor speed while monitoring the level of the vibration. When the vibration is at its maximum amplitude the motor frequency is the same as the resonant frequency. Since the probe is monitoring the vibrations of a specific part of the machine, you can find the resonance of that part independently.

When the vibration detector is being used near electric motors or alternators the electret microphone may pick up some interference from them. This is easily distinguished from vibration signals by its presence when the probe is removed from the vibrating surface.

The signals which you can hear on the earpiece can also be displayed on an oscilloscope by connecting the probes on to the terminals of a 3.5 mm plug inserted into the earphone socket. From the oscilloscope you can distinguish more clearly between the 'noise' and vibration, also you can make measurements of frequency and relative measurements of amplitude. ●





HOW IT WORKS — ETI-1530

A simple single 741 op-amp is used to amplify the signals picked up by the microphone. It is ac configured, that is, it only amplifies the ac signals. Direct current signals in the circuit remain unchanged, thus minimising the usual drift of the op-amp output.

Working from the input of the circuit to the output, the first component encountered is the microphone and its bias resistor R4. In the absence of any acoustic vibrations, R4 allows a dc bias current to flow into the microphone, thus developing a dc voltage across it. Any input into the mic will result in an ac voltage on top of the dc. Thus we say that the ac modulates the dc. The ac signal creeps through the capacitor C2 and is amplified by the op-amp.

The open loop (ie, with no loop between output and input) gain of the op-amp is enormous, typically thousands of times. This means that a small voltage difference between pin 2 and pin 3 will be amplified many thousands of times at the output. So, if this difference is 1 volt, will the output be 1000 V? Not at all. The op-amp supply is between 9 volts and ground, and this is the maximum swing that the output can achieve. In fact because of the voltage drop across the transistors in the output of the op-amp, the voltage can only approach the rails, not equal them.

The result of applying a large differential voltage to the input is just to slam the op-amp output up against the voltage rail. This means that any input signal picked-up will be hopelessly distorted. This is not what we want. Another problem is that the gain of an individual op-amp, although high, differs considerably from op-amp to op-amp. It also changes wildly with temperature. All these problems can be solved with feedback.

The classic feedback system, which we have used here, consists of a voltage divider, in which a small part of the output is taken back to the input; ac feedback is delivered here by R6 and R5.

Consider what happens when power is applied to the circuit. R1 and R2 form a voltage divider which sets a nominal 5.3 volts at their junction. The input impedance into the op-amp inputs is very high, so almost no voltage is lost across R3. Thus 5.3 volts is applied to pin 3. Since the voltage on pin 2 is still close to zero, because of the effect of C1 and C3, the output ramps up very quickly towards the positive rail. As it does so it takes the feedback loop with it, raising the voltage at the junction of R6 and R5. But as this voltage goes up it reduces the voltage difference between pins 2 and 3, thus reducing the output. When pin 2 reaches 5.3 volts, the voltage difference reaches zero. The output is also at 5.3 volts and no current is flowing in the feedback loop. So this is the dc, quiescent condition of the amplifier; dc gain is unity.

Now consider what happens when an input signal is applied to the mic. It passes through C2, and is applied to pin 3. Assume it is a positive going cycle, so pin 3 rises above pin 2. The op-amp output attempts to rise towards the 9 volt rail. This pulls pin 2 up until it cancels out the difference. A negative going pulse works in exactly the opposite fashion.

How much does the output move? The output has to rise sufficiently to bring pin 2 up to the same voltage as pin 3. Mathematically, this is realised by the expression:

$$\text{Gain} = \frac{R6+R5+RV1}{R5+RV1}$$

We have included RV1 to allow the user to set the gain over quite a wide range. The object of the exercise will always be to make the output swing up to the rails without actually clipping for a given input voltage.

Capacitor, C1, functions as a bootstrapping resistor to increase the impendance of the input. Consider that when the mic modulates the dc such that pin 3 goes positive, the only significant passage for current is via R3 into the supply rails. However, ac present on pin 3 is also present on pin 2. Thus if pin 2 and the junction of R1-R2 are coupled together an in-phase ac signal is created at both ends of R3, thus effectively increasing its resistance as seen from the mic.

SHOPAROUND

You should have all the parts you need for the **vibration detector** in your jiffy box. It's a real Saturday arvo project, this one. The **arbitrary waveform generator** consists of a whole bunch of common as mud bits and pieces as well, so you should have little trouble picking them up at the local corner store.

ETI-1530	**pc board**	**$2.00**
	front panel	**$3.50**
ETI-171	**pc board**	**$12.75**
	front panel	**$6.67**

MINIMART

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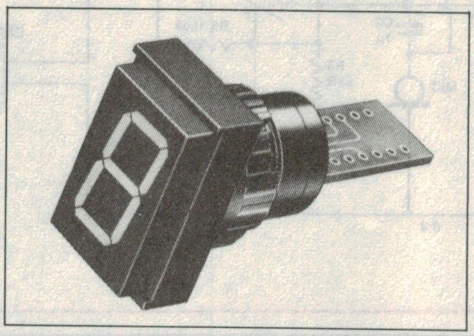

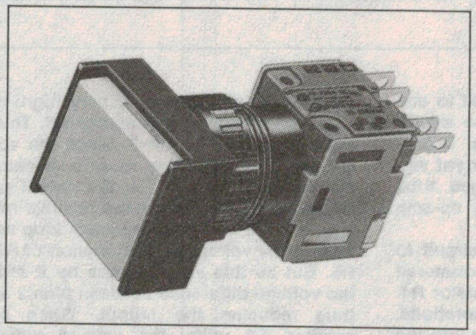

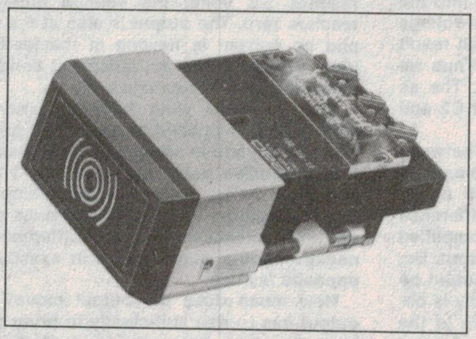

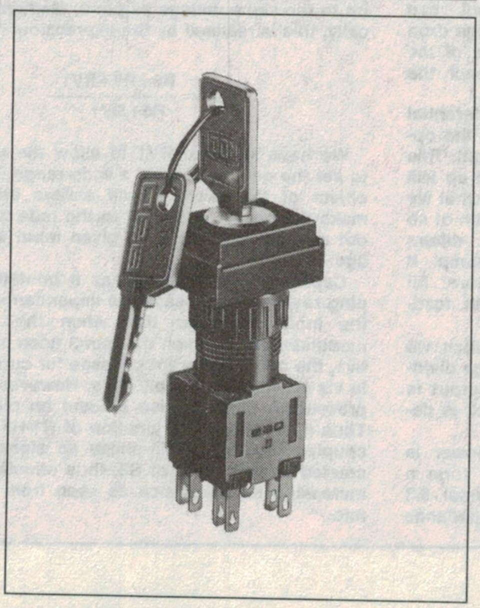

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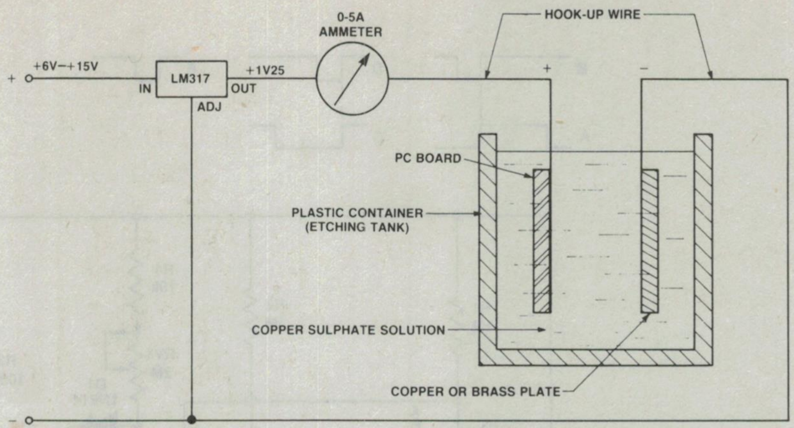
ASSOCIATED CONTROLS

Etching pc boards



This idea from **H. Nacinovich** can take some of the hassle out of etching and, possibly, save you money besides. It requires a low voltage power supply, a suitable plastic container for the etching process and a piece of copper or brass plate. A spare, unused pc board can be used for the latter. In addition, you will need some copper sulphate (sometimes sold as 'Bluestone') and a quantity of ferric chloride. The copper sulphate may be obtained from a chemist or, more cheaply, from a garden nursery supplier.

Dissolve 50 g of copper sulphate crystals in a litre of water (increase or decrease amounts as required) and pour into the plastic container sufficient to cover the pc board to be etched. Connect the pc board and the copper or brass plate as shown (in my case, I always leave a strip of copper along one edge of the pc board pattern for making a connection to a piece of hookup wire, either by soldering or by using an alligator clip.) Then, turn on the power and leave to etch.

When the ammeter reading falls to zero, turn off the power and remove the board. Then, immerse the board in a standard ferric chloride etching solution for a few minutes to clean up any incompletely etched areas on the board. You will find that this step doesn't take long and uses up very little ferric chloride, the ferric chloride will last much longer than it would if used for straight etching. The copper sulphate solution, on the other hand, does not get used up at all, and will last indefinitely.

The power supply can include any suitable source capable of supplying 1.5 A or more. However it is important that the actual voltage applied to the pc board in the etching tank be very low, around 1 to 2 V. An LM317 IC is ideal for obtaining the required low voltage.

Although this (electrolytic) method of etching is a little more complicated in setting up than in straight chemical etching, it can result in considerable cost savings in terms of chemicals when a lot of boards have to be etched.

'IDEA OF THE MONTH' CONTEST

Scope Laboratories, which manufactures and distributes soldering irons and accessory tools, is sponsoring this contest with a prize given away every month for the best item submitted for publication in the 'Ideas for Experimenters' column — one of the most consistently popular features in ETI Magazine. Each month we will be giving away a 60 W Portable Cordless Soldering Iron, a 240 Volt Charging Adaptor together with a Holder Bracket. The prize is worth approx. $100.

Selections will be made at the sole discretion of the editorial staff of ETI Magazine. Apart from the prize, each person will be paid $20 for an item published. You must submit original ideas of circuits which have not previously been published. You may send as many entries as you wish.

COUPON

Cut and send to: **Scope/ETI 'Idea of the Month' Contest, ETI Magazine, P.O. Box 227, Waterloo NSW 2017.**

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RULES

This contest is open to all persons normally resident in Australia, with the exception of members of the staff of Scope Laboratories, The Federal Publishing Company Pty Limited, ESN, The Litho Centre and/or associated companies.

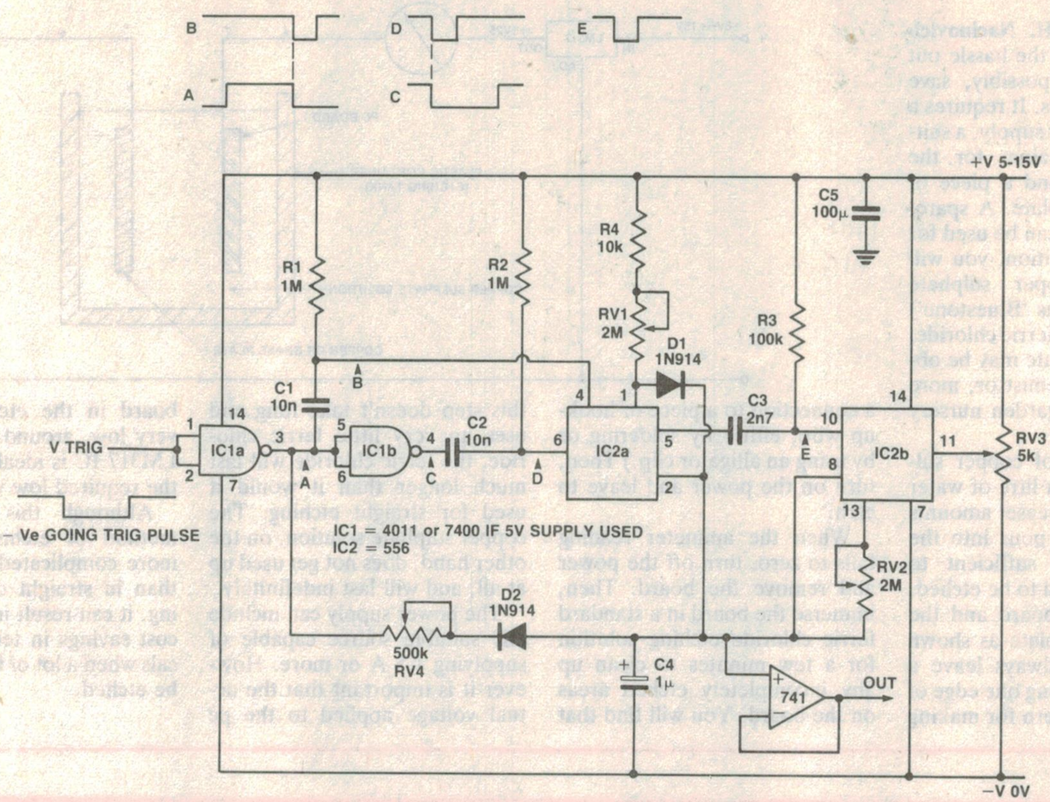
Closing date for each issue is the last day of the month. Entries received within seven days of that date will be accepted if postmarked to and including the date of the last day of the month.

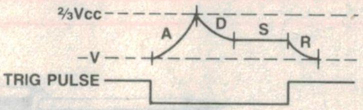
The winning entry will be judged by the editor of ETI Magazine, whose decision will be final. No correspondence can be entered into regarding the decision.

The winner will be advised by telegram the same day the result is declared. The name of the winner, together with the winning idea, will be published in the next possible issue of ETI Magazine.

Contestants must enter their names and addresses where indicated on each entry form. Photostats or clearly written copies will be accepted but if sending copies you must cut out and include with each entry the month and page number from the bottom of the page of the contest. In other words, you can send in multiple entries but you will need extra copies of the magazine so that you send an original page number with each entry.

This contest is invalid in states where local laws prohibit entries. Entrants must sign the declaration on the coupon that they have read the above rules and agree to abide by their conditions.





Envelope generator

James Moxham,
Urrbrae, SA 5064

This circuit is coupled to a simple VCA like those contained in *ETI Circuits* volume one.

It's based on '556 dual timer and half of a quad NAND gate. Operation starts with a trigger voltage from a keyboard. Notice that if the keyboard gives a positive voltage it will be necessary to invert it using one of the spare NAND gates. The existing inverter, IC1a, buffers the signal for delivery to a matrix of three RC networks, one of which is inverted by the other NAND gate, IC1b.

As soon as a trigger pulse arrives at IC1 it is turned into a narrow negative going pulse and applied to pin 6 of the first timer, IC2a. The discharge switch is turned off so C4 can charge up via RV1 and D1. This forms the attack section of the envelope. It is set by RV1. When the voltage reaches ⅔ of Vcc the comparator inside the timer resets the flipflop, and the discharge transistor behind pin 1 is turned on. However, C4 doesn't discharge because of the action of D1.

The negative going output from the timer is fed via another RC network to pin 10 of IC2. It's the reset pin of the second timer. When it is pulled low the discharge transistor in the second timer turns on and C4 discharges through RV2. This will continue until the voltage level reaches the trigger level which is set by RV3, so the sustain level can be adjusted.

The circuit holds this voltage until the key is released. When this happens, IC2a is reset via pin 4, and C4 discharges through D2 and RV4.

The output must be coupled via a high impedance input, or via a voltage follower where a buffered output is required.

PLAY 'LIFE' ON YOUR MICROBEE

'Life' is one of those games where the computer does all the hard bits and you just sit and watch. Not only is it fun to watch but it also has interesting roots in mathematics, cellular biology and cellular automata theory.

Jon McCormack

THE GAME OF LIFE was invented by a mathematician from the University of Cambridge, John Conway. Conway's background was in pure maths and he made some valuable contributions to group theory. In his spare time, however, he enjoyed inventing mathematical games. He published only a few of them — Life is one of those rarities.

Life is a simulation game where the rise and fall of a group of cells is mimicked. (The game does not bear too much in common with real cell growth patterns.) It was not originally meant for computers, but soon after being published, computer scientists spent much of their free time playing 'God' on their computers (more about this later).

The facts of life are simple. First you start with a grid (the bigger the better). A chess board is an example of what I mean by a grid, but for our purposes we'll use the Microbee screen. Normally 64 x 16 characters, the program converts the screen to 64 x 32 characters giving a total of 2048 locations. The player then inputs an initial pattern of cells (dots). After the initial pattern is finished the player (or computer) then applies the following rules to every space on the grid:

(a) Survival — each cell with two or three neighbours survives for the next generation.
(b) Death — any cell with four or more neighbours dies from overcrowding.
(c) Birth — any empty space (ie, where no cell is present) that has exactly three neighbours becomes a new cell.

The most important part of these rules is that births and deaths occur simultaneously (this means the newborn cells aren't really there until the next move and the dead cells don't die until the next move begins either). When these rules are applied to every space in the grid it's called a 'generation'.

Figure 1 shows what is meant by the term neighbours. A cell can have up to eight neighbours, these neighbours being the adjacent cells around the given cell. Figure 2 shows the fate of some simple patterns after a few generations.

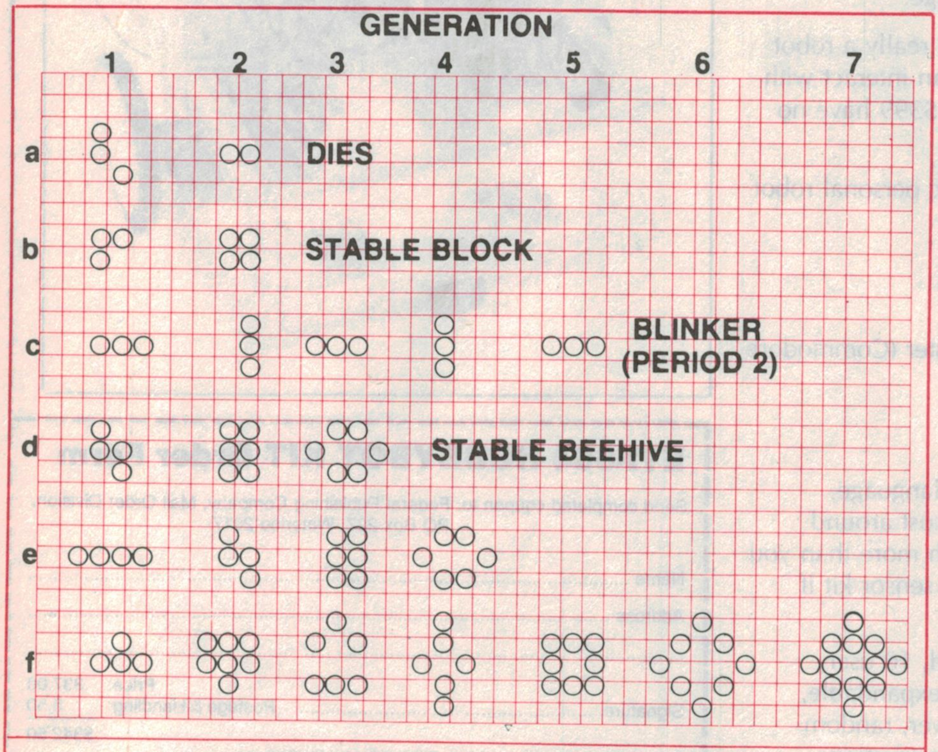


Figure 2. The fate of some simple patterns — (a) dies on the third generation, (b) is stable, (c) oscillates, (d) and (e) become stable, and (f) eventually becomes an oscillating pattern with a period of 2 (by generation 10).

Types of pattern

As can be seen from Figure 2 most cells either die or become stable patterns. A stable pattern neither grows nor dies — it just sits there (boring, eh?). The more you play Life the more you'll see these stable patterns. They fall into two groups. The first is the static, stable pattern which just sits there. The second is the oscillating pattern. All oscillating patterns neither grow nor die, however there is a sequence of patterns which they can assume. The simplest have a period of two, more complex ones may have 13 or 14 states.

One initial pattern, known as the 'R Pentomino' (Figure 3) has a huge lifespan (well

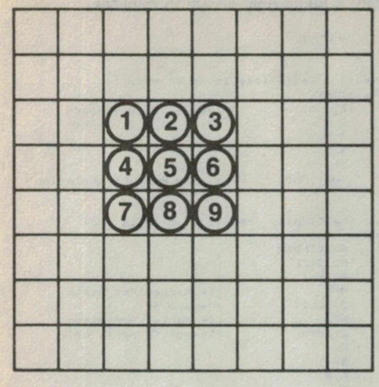


Figure 1. A small 'grid' (8 x 8), with 8 'cells'. Any cell may have between 0 and 8 neighbours. Cell 5, for example, has 8 neighbours, cells 1, 3, 7 and 9 have 3 neighbours. Cells 2, 4, 6 and 8 have 5 neighbours. The number of neighbours determines if the cell lives or dies, and if new cells are born.

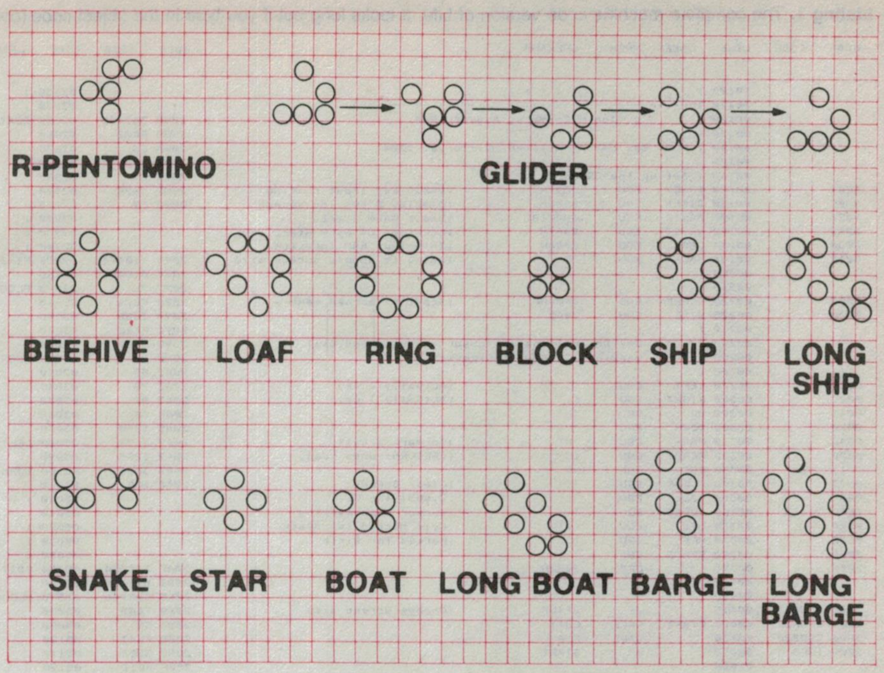


Figure 3. At top, the 'R-Pentomino' pattern which grows for several hundred generations (see also Figure 5) and a 'glider' pattern that moves across the grid. The bottom 12 patterns are the commonest stable patterns (their names are also shown).

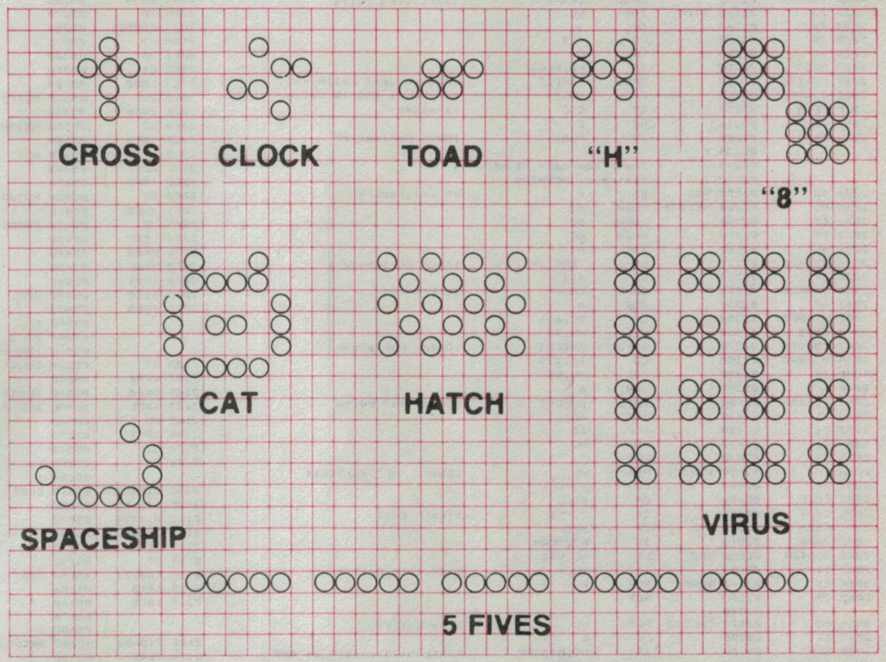


Figure 4. Several starting patterns to try; if you don't understand the names, wait till you watch them grow.

over 400 generations). It is hard to track its ultimate destiny as the size of the grid would be enormous! People have given names to the various common shapes and some of which are shown in the various figures. At first they don't look much like the names given but after a while it becomes second nature to recognise various patterns and know their ultimate fate (makes you feel kind of powerful, doesn't it!).

One very interesting pattern is called a 'glider'. The glider is an oscillating pattern, but it moves. The glider will go on moving forever (until it runs off the screen). Some gliders are shown in Figure 3.

'Cancer' patterns

When Conway first proposed the game of Life he challenged anyone to find a pattern that would grow without stopping. He felt so confident that none could be found that he offered a prize of $50 (a lot of money in those days, especially for a scientist). Having little to do during lunch hours, computer scientists all round America took up the challenge and began to run 'life simulators' on their computers in their spare time (or otherwise!). In November 1971 a team from the artificial intelligence group at MIT found a 'cancerous' group of cells. The pattern was nicknamed a 'glider gun' as every 30 generations it shot out gliders. Needless to say Conway ate his humble pie and surrendered his $50.

Well, a lot of cells have flown under the bridge since then and when home computers became popular everybody wanted to play Life. I had heard of Life but could not find a program to play it. If you want something done, do it yourself . . . as the saying goes.

The program

With such simple rules, Life is easy for a computer. I first wrote the program in BASIC, but it turned out to be far too slow (it took about 30 seconds between generations). Listing 1 shows the machine language version for the Microbee. It may look rather long, but trust me — it's worth typing in.

Even if you don't have the Editor/Assembler, just enter the monitor and ALTER 2000. Type in the hexadecimal numbers shown in the listing. If you don't have a monitor use BASIC poke statements (you'll ▶

Listing 1. The complete machine code version of Life. It looks long but if you type in the object code (code column) it takes only about 15 minutes.

```
ADDR   CODE    LINE  LABEL   MNEM    OPERAND

               ØØ1ØØ ;               l i f e .
               ØØ11Ø ;----------------------------------------
               ØØ12Ø ;       by Jon McCormack, August 1984.
               ØØ13Ø ;
               ØØ14Ø ; P.O. Box 247, Bentleigh, Victoria. 32Ø4
               ØØ15Ø ;
               ØØ16Ø ; Set up the EQU's :
8ØØ9           ØØ17Ø INKEY   EQU     8ØØ9H             ;BASIC key input routine
8ØØC           ØØ18Ø DISPB   EQU     8ØØCH             ;Display B reg. on screen
8Ø21           ØØ19Ø BASIC   EQU     Ø8Ø21H            ;Basic Warm Start
ØØA2           ØØ192 RESET   EQU     ØØA2H             ;Location of warm start jump
ØØDA           ØØ194 LACE    EQU     ØØDAH             ;Interlace RAM location
ØØ4B           ØØ196 HALF    EQU     75                ;Value to double screen size
               ØØ2ØØ ;
               ØØ21Ø ;
FØØØ           ØØ22Ø SCREEN  EQU     ØFØØØH            ;Start of screen memory
Ø8ØØ           ØØ225 SIZE    EQU     2Ø48
               ØØ23Ø ;
               ØØ24Ø ;       Key Definitions for cusor movement and Cell
               ØØ25Ø ;       marking. Change as necessary.
               ØØ26Ø ;
ØØ2C           ØØ27Ø LEFT    EQU     ','               ;Actually < key
ØØ2E           ØØ28Ø RIGHT   EQU     '.'               ;Actually > key
ØØ4C           ØØ29Ø UP      EQU     'L'
ØØ2Ø           ØØ3ØØ DOWN    EQU     ' '
ØØ4D           ØØ31Ø MARK    EQU     'M'               ;To mark a Cell
ØØØD           ØØ32Ø READY   EQU     13                ;<RETURN> when ready
ØØ1B           ØØ33Ø ESC     EQU     27
ØØ43           ØØ34Ø CLEAR   EQU     'C'               ;Clear Screen
ØØ6F           ØØ35Ø CELL    EQU     'o'               ;Symbol for Cell
ØØ58           ØØ36Ø CURSOR  EQU     'X'               ;Cursor when marking
ØØ2A           ØØ37Ø MFD     EQU     '*'               ;Cell Marked for death
ØØ2E           ØØ38Ø MFB     EQU     '.'               ;Marked for Birth
ØØ2Ø           ØØ39Ø SPACE   EQU     ' '
2ØØØ           ØØ395         ORG     2ØØØH
               ØØ4ØØ ;
               ØØ41Ø ;
2ØØØ C32121    ØØ415         JP      SETUP             ;Change screen size
2ØØ3 CDAF2Ø    ØØ42Ø START   CALL    EDIT
2ØØ6 CDØB2Ø    ØØ43Ø         CALL    PLAY
2ØØ9 18F8      ØØ44Ø         JR      START
               Ø2ØØØ ;
               Ø2Ø1Ø ;       PLAY
               Ø2Ø2Ø ;       This section of code Plays life from the
               Ø2Ø3Ø ;       current status of the screen.
               Ø2Ø4Ø ;       Destroys: MOST
2ØØB 21ØØFØ    Ø2Ø5Ø PLAY    LD      HL,SCREEN
2ØØE Ø1ØØØ8    Ø2Ø6Ø         LD      BC,SIZE
2Ø11 CD352Ø    Ø2Ø7Ø PLOOP   CALL    NEIGHB            ;Check how many neighbour
2Ø14 CD782Ø    Ø2Ø8Ø         CALL    BIRTH
2Ø17 7E        Ø2Ø9Ø         LD      A,(HL)            ;Get val
2Ø18 FE2Ø      Ø21ØØ         CP      SPACE             ;Blank
2Ø1A 28Ø7      Ø211Ø         JR      Z,SKIP
2Ø1C FE2E      Ø212Ø         CP      MFB               ;Marked for life
2Ø1E 28Ø3      Ø213Ø         JR      Z,SKIP
2Ø2Ø CD852Ø    Ø214Ø         CALL    DEATH             ;Serviving Cells
2Ø23 23        Ø215Ø SKIP    INC     HL
2Ø24 ØB        Ø216Ø         DEC     BC
2Ø25 78        Ø217Ø         LD      A,B
2Ø26 B1        Ø218Ø         OR      C
2Ø27 2ØE8      Ø219Ø         JR      NZ,PLOOP
2Ø29 CD912Ø    Ø22ØØ         CALL    FIXDIS            ;Remove dead cells etc
2Ø2C CDØ98Ø    Ø2212         CALL    INKEY             ;Check if ESC is being
2Ø2F FE1B      Ø2214         CP      ESC               ;pressed
2Ø31 C8        Ø2216         RET     Z
2Ø32 18D7      Ø222Ø         JR      PLAY              ;Next Generation
               Ø223Ø ;
               Ø224Ø ;       Check how many neighbours
               Ø225Ø ;       Destroys: NOTHING
2Ø34 ØØ        Ø2255 NOC     DB      Ø                 ;# neighbours
2Ø35 E5        Ø226Ø NEIGHB  PUSH    HL
2Ø36 C5        Ø228Ø         PUSH    BC
2Ø37 F5        Ø229Ø         PUSH    AF
2Ø38 AF        Ø23ØØ         XOR     A
2Ø39 32342Ø    Ø231Ø         LD      (NOC),A           ;Zero #neighbours
2Ø3C 3EØ1      Ø232Ø         LD      A,1
2Ø3E CD662Ø    Ø233Ø         CALL    CHECK3            ;Check row
2Ø41 AF        Ø234Ø         XOR     A
2Ø42 Ø14ØØØ    Ø235Ø         LD      BC,64
2Ø45 ED42      Ø236Ø         SBC     HL,BC
2Ø47 CD662Ø    Ø237Ø         CALL    CHECK3            ;Check Row above
2Ø4A Ø18ØØØ    Ø238Ø         LD      BC,128
2Ø4D Ø9        Ø2382         ADD     HL,BC
2Ø4E AF        Ø2399         XOR     A
2Ø4F CD662Ø    Ø24ØØ         CALL    CHECK3            ;Check Row below
2Ø52 F1        Ø241Ø         POP     AF
2Ø53 C1        Ø242Ø         POP     BC
2Ø54 E1        Ø243Ø         POP     HL
2Ø55 C9        Ø244Ø         RET
2Ø56 E5        Ø245Ø CHECK1  PUSH    HL                ;Check (HL) for Cell
2Ø57 7E        Ø246Ø         LD      A,(HL)
2Ø58 FE6F      Ø248Ø         CP      CELL
2Ø5A 28Ø4      Ø249Ø         JR      Z,YES             ;Yes - Cell
2Ø5C FE2A      Ø25ØØ         CP      MFD
2Ø5E 2ØØ4      Ø251Ø         JR      NZ,SORRY
2Ø6Ø 21342Ø    Ø252Ø YES     LD      HL,NOC
2Ø63 34        Ø253Ø         INC     (HL)              ;Add 1 to Cell #
2Ø64 E1        Ø254Ø SORRY   POP     HL
2Ø65 C9        Ø255Ø         RET
               Ø256Ø ;
2Ø66 E5        Ø257Ø CHECK3  PUSH    HL                ;Check 1 row
2Ø67 B7        Ø259Ø         OR      A
2Ø68 2ØØ3      Ø26ØØ         JR      NZ,MIDSKP         ;Skip middle cell if A=Ø
2Ø6A CD562Ø    Ø261Ø         CALL    CHECK1
2Ø6D 2B        Ø262Ø MIDSKP  DEC     HL
2Ø6E CD562Ø    Ø263Ø         CALL    CHECK1
2Ø71 23        Ø264Ø         INC     HL
2Ø72 23        Ø265Ø         INC     HL
2Ø73 CD562Ø    Ø266Ø         CALL    CHECK1
2Ø76 E1        Ø267Ø         POP     HL
2Ø77 C9        Ø268Ø         RET
               Ø269Ø ;
               Ø27ØØ ;       BIRTH routine
               Ø271Ø ;       Checks for New Cells and marks them.
               Ø272Ø ;       Destroys: AF
2Ø78 7E        Ø273Ø BIRTH   LD      A,(HL)
2Ø79 FE2Ø      Ø274Ø         CP      SPACE
2Ø7B [illegible] Ø275Ø       RET     NZ
2Ø7C 3A342Ø    Ø276Ø         LD      A,(NOC)
2Ø7F FEØ3      Ø277Ø         CP      3                 ;Check if 3 neighbours
2Ø81 CØ        Ø278Ø         RET     NZ
2Ø82 362E      Ø279Ø         LD      (HL),MFB          ;A Cell is born !!
2Ø84 C9        Ø28ØØ         RET
               Ø281Ø ;
               Ø282Ø ;       DEATH routine
               Ø283Ø ;       Checks if a Cells life is at an end.
               Ø284Ø ;       Destroys: AF
2Ø85 3A342Ø    Ø285Ø DEATH   LD      A,(NOC)           ;Get # of neighbours
2Ø88 FEØ2      Ø286Ø         CP      2                 ;If = to 2 or 3 then
2Ø8A C8        Ø287Ø         RET     Z                 ; return
2Ø8B FEØ3      Ø288Ø         CP      3
2Ø8D C8        Ø289Ø         RET     Z
2Ø8E 362A      Ø29ØØ         LD      (HL),MFD          ; else Mark For Deletion
2Ø9Ø C9        Ø291Ø         RET
               Ø292Ø ;
               Ø293Ø ;       FIX up the DISplay (remove dead cells etc)
               Ø294Ø ;       Destroys: Most
2Ø91 21ØØFØ    Ø295Ø FIXDIS  LD      HL,SCREEN
2Ø94 Ø1ØØØ8    Ø296Ø         LD      BC,SIZE
2Ø97 7E        Ø297Ø FLOOP   LD      A,(HL)
2Ø98 FE2A      Ø298Ø         CP      MFD               ;If Marked For Death
2Ø9A 28ØB      Ø299Ø         JR      Z,DELIT           ;Remove it!
2Ø9C FE2E      Ø3ØØØ         CP      MFB               ;If Marked For Birth
2Ø9E 28ØB      Ø3Ø1Ø         JR      Z,BORN            ;Change to adult cell
2ØAØ 23        Ø3Ø2Ø FNEXT   INC     HL
2ØA1 ØB        Ø3Ø3Ø         DEC     BC
2ØA2 78        Ø3Ø4Ø         LD      A,B
2ØA3 B1        Ø3Ø5Ø         OR      C
2ØA4 C8        Ø3Ø6Ø         RET     Z                 ;If all cells tested,end
2ØA5 18FØ      Ø3Ø7Ø         JR      FLOOP
2ØA7 362Ø      Ø3Ø8Ø DELIT   LD      (HL),SPACE
2ØA9 18F5      Ø3Ø9Ø         JR      FNEXT
2ØAB 366F      Ø31ØØ BORN    LD      (HL),CELL
2ØAD 18F1      Ø311Ø         JR      FNEXT
               Ø5ØØØ ;       E D I T  routine.
               Ø5Ø1Ø ;       This routine allows the user to edit the cells
               Ø5Ø2Ø ;       on the screen. Fubctions : Up,Down,Left,Right
               Ø5Ø3Ø ;       Mark,Clear Screen and Ready.
               Ø5Ø4Ø ;       Destroys : Most
2ØAF 211CF4    Ø5Ø5Ø EDIT    LD      HL,SCREEN+1Ø52    ; Middle of 64x32 screen
2ØB2 Ø14ØØØ    Ø5Ø6Ø         LD      BC,64             ; Difference between line
2ØB5 CDØ98Ø    Ø5Ø7Ø MLOOP   CALL    INKEY
2ØB8 FEØD      Ø5Ø8Ø         CP      READY             ; Finished ?
2ØBA C8        Ø5Ø9Ø         RET     Z
2ØBB FE43      Ø51ØØ         CP      CLEAR             ; Check if CLS
2ØBD 285B      Ø511Ø         JR      Z,CLS
2ØBF FE1B      Ø512Ø         CP      ESC               ; End ?
2ØC1 CA218Ø    Ø513Ø         JP      Z,BASIC
2ØC4 FE2C      Ø514Ø         CP      LEFT
2ØC6 281D      Ø515Ø         JR      Z,MLEFT
2ØC8 FE2E      Ø516Ø         CP      RIGHT
2ØCA 281C      Ø517Ø         JR      Z,MRIGHT
2ØCC FE4C      Ø518Ø         CP      UP
2ØCE 281B      Ø519Ø         JR      Z,MUP
2ØDØ FE2Ø      Ø52ØØ         CP      DOWN
2ØD2 281C      Ø521Ø         JR      Z,MDOWN
2ØD4 FE4D      Ø522Ø         CP      MARK
2ØD6 281B      Ø523Ø         JR      Z,MMARK
2ØD8 C5        Ø524Ø PDIS    PUSH    BC                ;Display Cusor on screen
2ØD9 7E        Ø525Ø         LD      A,(HL)
2ØDA Ø658      Ø526Ø         LD      B,CURSOR
2ØDC 7Ø        Ø527Ø         LD      (HL),B            ;Put cusor at (HL)
2ØDD CDØØ21    Ø528Ø         CALL    DELAY             ;Wait a bit
2ØEØ 47        Ø529Ø         LD      B,A               ;Put old char back
2ØE1 7Ø        Ø53ØØ         LD      (HL),B            ;onto screen
2ØE2 C1        Ø531Ø         POP     BC
2ØE3 18DØ      Ø532Ø         JR      MLOOP             ;Back to start
2ØE5 2B        Ø533Ø MLEFT   DEC     HL                ;Move left
2ØE6 18FØ      Ø534Ø         JR      PDIS
2ØE8 23        Ø535Ø MRIGHT  INC     HL                ;Move right
2ØE9 18ED      Ø536Ø         JR      PDIS
2ØEB B7        Ø537Ø MUP     OR      A
2ØEC ED42      Ø538Ø         SBC     HL,BC             ;Move up
2ØEE 18E8      Ø539Ø         JR      PDIS
2ØFØ Ø9        Ø54ØØ MDOWN   ADD     HL,BC             ;Move down
2ØF1 18E5      Ø541Ø         JR      PDIS
2ØF3 7E        Ø542Ø MMARK   LD      A,(HL)            ;Mark Cell
2ØF4 FE6F      Ø543Ø         CP      CELL              ;If Cell there then
2ØF6 28Ø4      Ø544Ø         JR      Z,CDEL            ;remove it
2ØF8 366F      Ø545Ø         LD      (HL),CELL         ;Show Cell
2ØFA 18B9      Ø546Ø         JR      MLOOP             ;Return
2ØFC 362Ø      Ø547Ø CDEL    LD      (HL),SPACE        ;Delete Cell
2ØFE 18B5      Ø548Ø         JR      MLOOP             ;Return
               Ø549Ø ;
               Ø55ØØ ;       DELAY Routine
               Ø551Ø ;Short delay, Destroys nothing.
21ØØ C5        Ø552Ø DELAY   PUSH    BC
21Ø1 ØEØ4      Ø553Ø         LD      C,4
21Ø3 Ø6ØØ      Ø554Ø BLOOP   LD      B,Ø
21Ø5 1ØFE      Ø555Ø DLOOP   DJNZ    DLOOP
21Ø7 ØD        Ø556Ø         DEC     C
21Ø8 2ØF9      Ø557Ø         JR      NZ,BLOOP
21ØA C1        Ø558Ø         POP     BC
21ØB C9        Ø559Ø         RET
               Ø56ØØ ;
21ØC 21ØØFØ    Ø561Ø CLSS    LD      HL,SCREEN         ;Clear Screen
21ØF 11Ø1FØ    Ø562Ø         LD      DE,SCREEN+1       ;Dest.
2112 Ø1ØØØ8    Ø563Ø         LD      BC,SIZE           ;Screen Size
2115 362Ø      Ø564Ø         LD      (HL),SPACE        ;Blank 1st location
2117 EDBØ      Ø565Ø         LDIR                      ;Zap the rest
2119 C9        Ø5652         RET
211A CDØC21    Ø5654 CLS     CALL    CLSS
211D 189Ø      Ø5656         JR      EDIT
211F 188E      Ø566Ø         JR      EDIT              ;Back to start
               Ø567Ø ;
               Ø568Ø ;       Set up routine , changes screen size
2121 21DAØØ    Ø569Ø SETUP   LD      HL,LACE
2124 364B      Ø57ØØ         LD      (HL),HALF         ; Double screen size
2126 212F21    Ø571Ø         LD      HL,NEXTIN         ; Jump after reset address
2129 22A2ØØ    Ø572Ø         LD      (RESET),HL        ; Save address
212C C3ØØ8Ø    Ø573Ø         JP      8ØØØH             ; Reset
212F CDØC21    Ø574Ø NEXTIN  CALL    CLSS              ; Clear screen
2132 C3Ø32Ø    Ø575Ø         JP      START             ; Let the game begin
ØØØØ           Ø576Ø         END
ØØØØØ Total errors

NEXTIN  212F   CLSS    21ØC   DLOOP   21Ø5   BLOOP   21Ø3
CDEL    2ØFC   DELAY   21ØØ   PDIS    2ØD8   MMARK   2ØF3
MDOWN   2ØFØ   MUP     2ØEB   MRIGHT  2ØE8   MLEFT   2ØE5
CLS     211A   MLOOP   2ØB5   FNEXT   2ØAØ   BORN    2ØAB
DELIT   2ØA7   FLOOP   2Ø97   MIDSKP  2Ø6D   SORRY   2Ø64
YES     2Ø6Ø   CHECK1  2Ø56   CHECK3  2Ø66   NOC     2Ø34
FIXDIS  2Ø91   DEATH   2Ø85   SKIP    2Ø23   BIRTH   2Ø78
NEIGHB  2Ø35   PLOOP   2Ø11   PLAY    2ØØB   EDIT    2ØAF
START   2ØØ3   SETUP   2121   SPACE   ØØ2Ø   MFB     ØØ2E
MFD     ØØ2A   CURSOR  ØØ58   CELL    ØØ6F   CLEAR   ØØ43
ESC     ØØ1B   READY   ØØØD   MARK    ØØ4D   DOWN    ØØ2Ø
UP      ØØ4C   RIGHT   ØØ2E   LEFT    ØØ2C   SIZE    Ø8ØØ
SCREEN  FØØØ   HALF    ØØ4B   LACE    ØØDA   RESET   ØØA2
BASIC   8Ø21   DISPB   8ØØC   INKEY   8ØØ9
```

have to convert hex to decimal). Alternatively, send $9 to the author for a post paid cassette (deluxe version, too long to list here).

Once you have entered the program, save it (just in case you've made a mistake) then jump to address 2000 hex. The first thing you will notice is that the screen has changed size — it's now 64 x 32. Somewhere around the middle of the screen you should see an X. This is the cursor to input your initial pattern. You can move the cursor around by using the < and > keys (left and right), the L key for up and the space bar for down. To clear the screen press the letter C, and to toggle a cell (ie, make it appear if it's not there, disappear if it is) press the M key. To escape back to BASIC press the ESC key.

Using the cursor and M keys, put in your initial pattern (try the 'R Pentomino', for example). When you've finished press RETURN. Now the action starts — before your eyes you should see each generation come and go. If you wish to stop the proceedings hold down the ESC key and you will be returned to the 'edit' mode. Here you can change cells round or just leave them; press RETURN and the action will start again. In most cases after a while the pattern will die or become stable. When you get sick of watching a stable pattern ESC to the edit mode, clear the screen (C key) and start again.

Operation of the program is in simple steps. The first SETUP sets up the screen to the 64 x 32 format. This is done by changing one of the registers in the 6545 video chip. The subroutine EDIT moves the cursor round and marks cells. Note that, in the interests of saving space, this routine does not check if the cursor has moved right off the screen — so be careful. Once EDIT is finished with, the subroutine PLAY comes into action. In this routine each space on the entire grid is scanned. First the program finds out how many neighbours the space has. If there are three neighbours a new cell is born. New cells first appear as a . on the screen. Then, if the space contains a cell (not a newborn one) it is checked for survival. If a cell is about to die it appears as a * on the screen. Once the whole screen has been checked all the dead cells are removed and the newborn ones 'grow' to full-sized cells. This process is repeated until the ESC key is pressed. The program comments give more details.

If you don't like the cursor keys (< ,>,l,SPACE) you can change the EQU statements (lines 270-300) to whatever you desire. The characters of the live, dead, and newborn cells can be changed also (lines 350-380). If you do change these values you'll have to reassemble the program.

The program runs some 30-40 times faster than the BASIC version and completes about one generation every 0.7 seconds (ie, fast). A small problem arises when cells hit the edge of the screen — they tend to stick to the edge if at the top or roll over at the sides of the screen (the grid is actually a type of cylinder). The reason for this is that the program can only check up to the size of the grid, even though several patterns will grow bigger than the grid itself.

It is easy to add more features such as a generation count or a routine to print the screen at any time (that's how some of the figures were obtained). These were too long to be shown in the listing, however.

There are thousands of possible patterns, and the best ones are usually the simplest. Figure 4 shows some more interesting ones. Since Conway's invention of the game of Life, many variations have been devised. Some involve the use of 'virus' cells which attack a colony of normal cells and may or may not kill them off. More complex variations involve different types of cells, each with their own rules for birth, death and survival, plus interaction with hostile cells. Some of these variations run a little closer to the reality of real cell growth and cellular atomata theory. If you want more information read the Mathematical Games section of the *Scientific American,* October 1970, pages 120-123. So start typing and play God on your 'Bee . . . ●

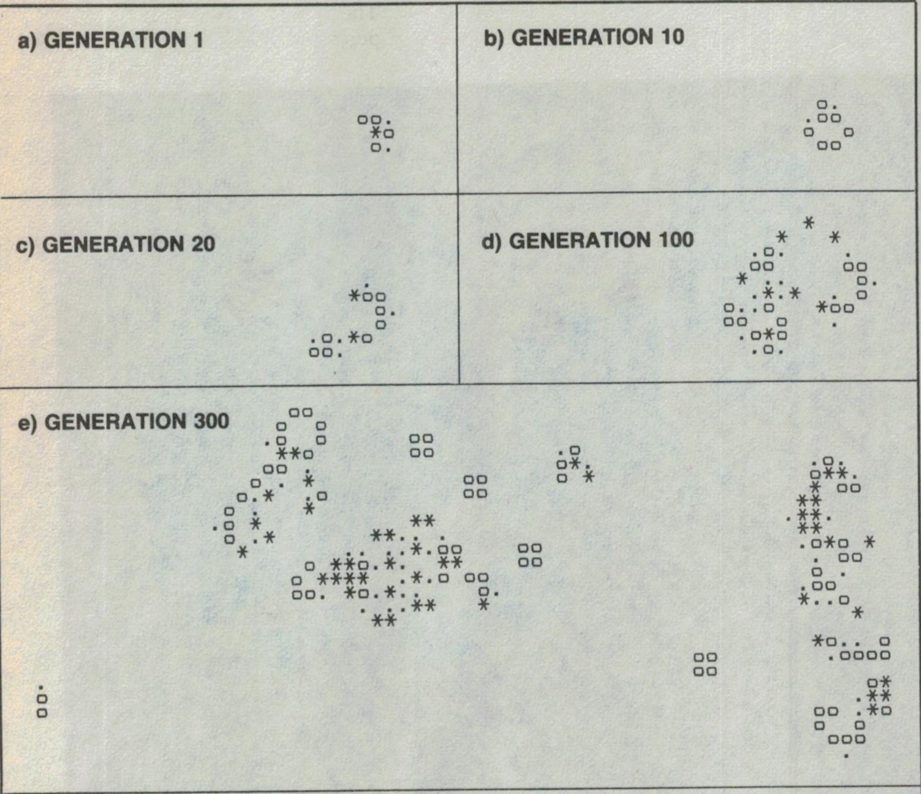
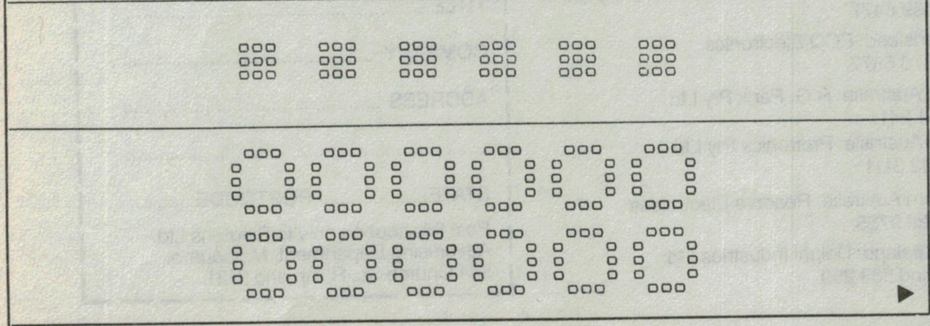
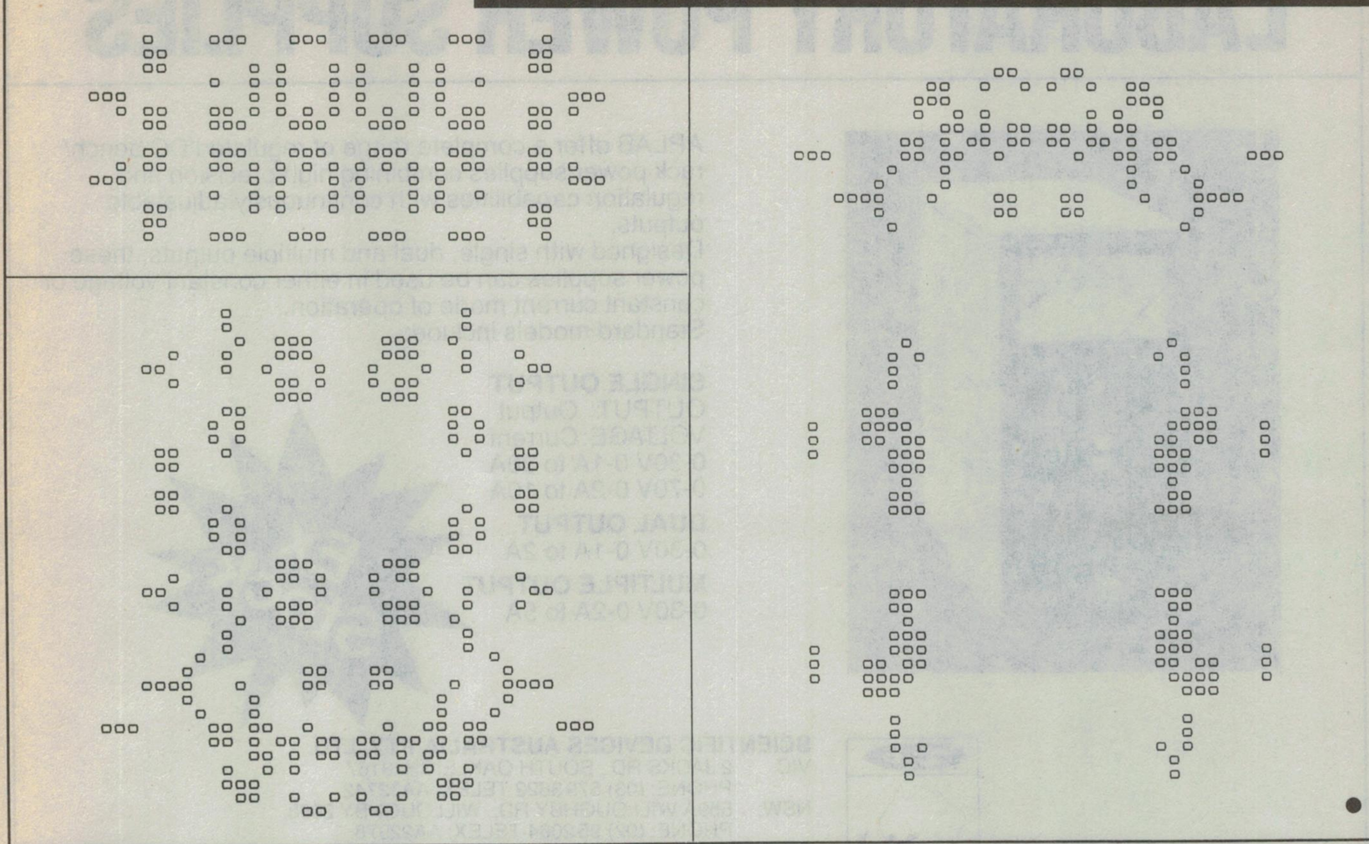


Figure 5. The R-Pentomino after (a) 1 generation, (b) 10 generations, (c) 20 generations, (d) 100 generations and (e) 300 generations. The dots (.) are newborn cells and the asterisks (*) are cells that are about to die.

Figure 6. Various stages in the growth of an initial pattern of six blocks. The pattern grows so big it flows off the screen.





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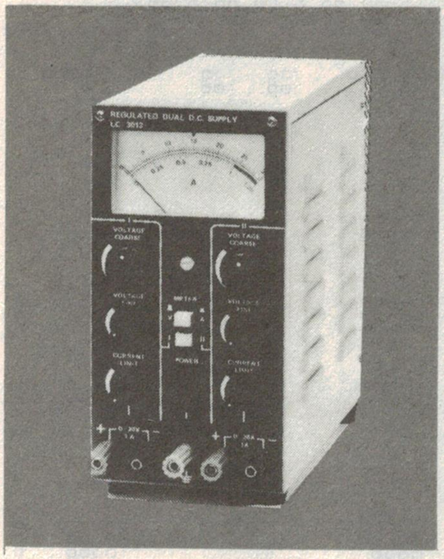

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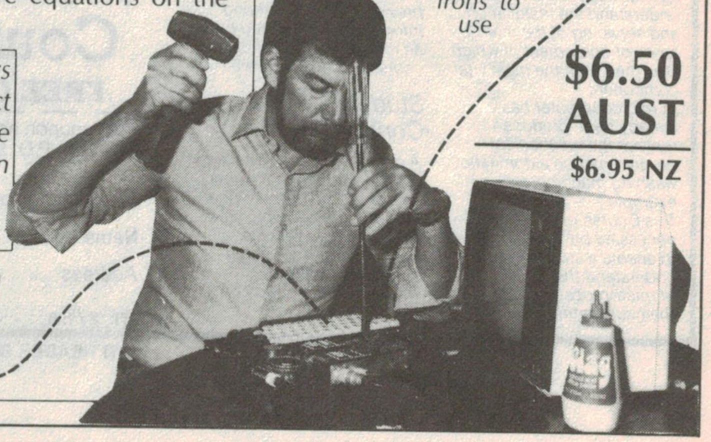

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MODIFYING THE VZ200 16K EXPANSION MODULE FOR THE VZ300

Steve Olney

This article describes a method of remapping a DSE VZ200 16K RAM expansion module preventing overlap of memory space when used on a VZ300. The cost is limited to the price of one integrated circuit chip plus a single-pole double-throw switch if dual VZ200/300 compatibility is desired. The modification is fitted inside the expansion module case.

MANY OF YOU who have updated to the new version VZ300 must be disappointed to realise that although the VZ300 comes with much more internal RAM as standard (18K as against 8K for the VZ200), use of your old VZ200 16K expansion module on the VZ300 only results in the same total memory as that which was available on the older VZ200 with the expansion module plugged in.

The reason for this becomes clear when a comparison is made between the memory maps of the VZ200 and the VZ300 as shown in Figure 1. If a VZ200 16K expansion module is plugged into a VZ300, about 10K of the expansion RAM overlaps memory space already provided to the VZ300 internally. This results in only 6144 bytes of extra memory. In order to make proper use of the expansion memory space, the start of the VZ200 expansion module needs to be moved or remapped to the end of the VZ300 internal memory instead of somewhere in the middle. For more details on the memory map of the VZ200 and VZ300, refer to Jim Rowe's informative article on the VZ300, ETI July 1985.

The object of this article is to provide information sufficient to modify a VZ200 16K expansion module to be used on both your VZ200 as well as your new VZ300.

Before proceeding there are a few words of advice for those wishing to undertake the modification:

1. Because you are modifying an existing working unit, this project is intended for those with reasonable soldering skills and at least some experience with digital components. If you are unsure, enlist the aid of someone capable (and willing) to carry out the modification.

2. Remember, modification to your module will render the module warranty void, although I expect most modules would be out of warranty anyway.

3. The modification details provided are for printed circuit boards identified by the '700352 F' designation. If you find a different number near where the seven ICs are located, then be careful to ensure that all mechanical details supplied here agree with your board. If they don't, I advise you not to proceed unless you have sufficient knowledge to adapt the circuit for that board.

The circuit

Modifying the address decoding logic to remap the expansion RAM only requires two extra AND gates, so half a 74LS08 IC is all that is really needed, but I used NAND gates. The reason for this is that quite often, when a design is completed, extra input sig-

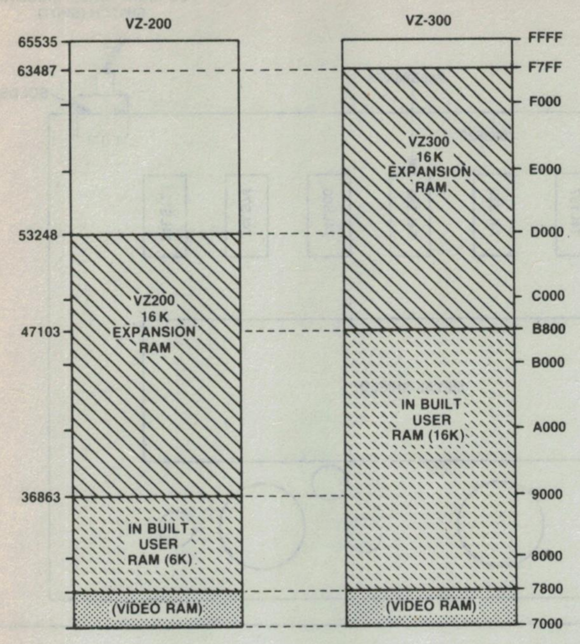

Figure 1. The memory maps for the VZ-200 and VZ-300. Note how their internal and expansion RAMs cover different address ranges.

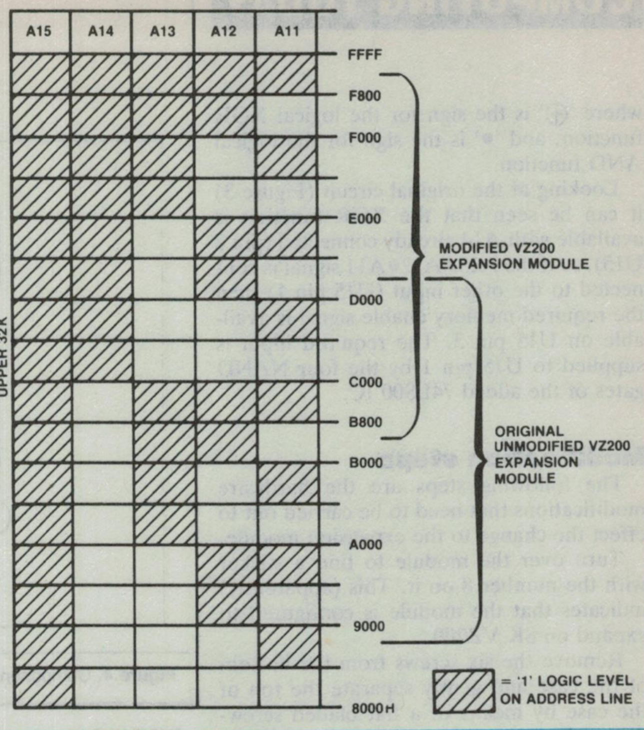

Figure 2. Address decoding map.

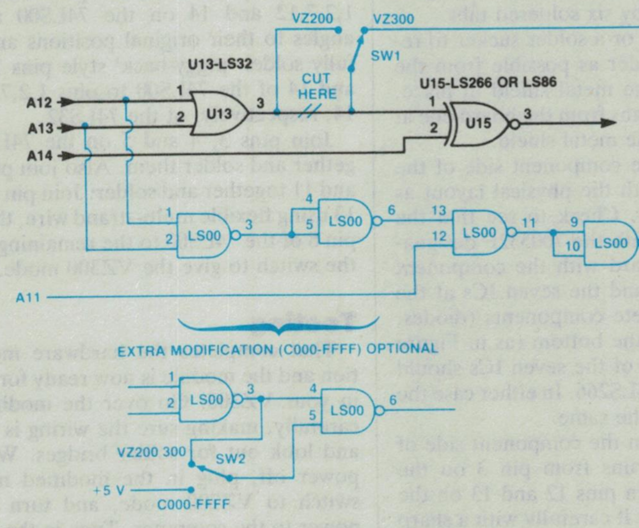

Figure 3. Modification details.

nals or controls are required. Because NAND or NOR gates can be configured to implement all of the basic logic functions, they are often used in at least some part of a circuit — even when that part could be more efficiently designed with other logic units. This is done with the view that if modification is required, then spare NAND or NOR gates allow some flexibility.

To further illustrate this point, it occurred to me, after working out the circuit, that it might be useful to have a block of RAM separated completely from the contiguous internal RAM for such purposes as having a reserved area of memory for running machine code programs, or implementing a printer buffer in RAM under software control. To do this the 16K RAM pack could be remapped to extend from C000H to the top of addressable memory, FFFFH. This would result in a 2K byte gap (for the VZ300 only) between the end of internal memory and the start of the expansion memory. When the BASIC interpreter seeks the top of memory, it is unable to jump this gap and so the top of memory pointers are set to the end of internal memory. This creates a reserved 16K block of RAM from C000H to FFFFH. That is, the top of memory pointers in BASIC are set to the same values as for a VZ without expansion module. This would still mean, of course, 18K for the VZ300, but only 8K for the VZ200. If the original circuit was implemented with AND gates the circuit would have to be re-designed. However, because NAND gates are being used, one of the paralleled inputs of one NAND gate can simply be switched to implement this change. This is shown in Figure 3.

The decoding logic

Those who are not curious about the decoding logic details can skip this section and go straight on to the modifications.

To work out the new decoding required, a graphical method was used. By looking at Figure 2, we can see that A14 = 1 (address line 14 = 1) covers from C000H to FFFFH (49152 to 65535 decimal). However, this is 2K bytes too high; the top 2K bytes need to be disabled, and 2K bytes added to the bottom, in order to enable a block extending from B800H to F7FFH (47104 to 63487 decimal). That is, from the end of the VZ300 internal memory on up. It might be noted that from F800H to FFFFH (where the memory should *not* be enabled) A13, A12 and A11 are = 1. Also from B800H to C000H (where the memory *should* be enabled) A13, A12 and A11 are again = 1. The only difference is that A14 = 1 in the first case, and = 0 in the second case. In other words, the memory should be enabled when A14 = 1 or when A13 and A12 and A11 all = 1, except when they all (A14-A11) = '1' at the same time. In logical shorthand this is written as:

$$A14 \oplus (A13 \bullet A12 \bullet A11)$$

where '⊕' is the sign for the logical XOR function, and '•' is the sign for the logical AND function.

Looking at the original circuit (Figure 3) it can be seen that the XOR function is available with A14 already connected (pin 2 U15), so if the A13•A12•A11 signal is connected to the other input (U15 pin 1) then the required memory enable signal is available on U15 pin 3. The required input is supplied to U15 pin 1 by the four NAND gates of the added 74LS00 IC.

Modification steps

The following steps are the hardware modifications that need to be carried out to effect the change to the expansion module.

Turn over the module to find a sticker with the number 8 on it. This (apparently) indicates that the module is configured to expand on 8K VZ200.

Remove the six screws from the bottom of the case and gently separate the top of the case by means of a flat bladed screwdriver. Do this at the connector end of the module first, as there is a tendency for the cover to jam if it is pulled off at an angle. This will reveal a pc board to which a metal shield is attached by six soldered tabs.

Use solder wick or a solder sucker to remove as much solder as possible from the six tabs holding the metal shield in place, *gently* freeing the tabs from the board one at a time. Remove the metal shield.

At this point the component side of the board is visible with the physical layout as shown in Figure 4. Check to see that the board is marked with the 700532F designation. Hold the board with the component side towards you and the seven ICs at the top, and the discrete components (diodes, transistors etc) at the bottom (as in Figure 4). The middle IC of the seven ICs should be a 74LS86 or a 74LS266. In either case the modifications are the same.

Find the track on the component side of the board which runs from pin 3 on the 74LS232 to between pins 12 and 13 on the 74LS86/266 and cut it carefully with a sharp knife as in Figure 5.

Decide where to mount the SPDT change-over switch. I soldered a right angle pcb mounting type to the board itself (see Figure 4). You will probably need to shorten the terminal legs of the switch first and make sure the switch will not foul the metal shield when it is re-fitted. Another arrangement would be to mount the switch through a hole drilled in the top part of the plastic case. This is satisfactory providing the switch protruding out does not foul the printer or joystick interface plugged in next to it.

Using multi-strand insulated wire (wire stripped from rainbow ribbon cable is excellent) connect the centre (or common) terminal of the change-over switch to pin 1 of the 74LS86/266, then connect pin 3 of the 74LS32 to one side of the switch (this position will select normal VZ200 operation).

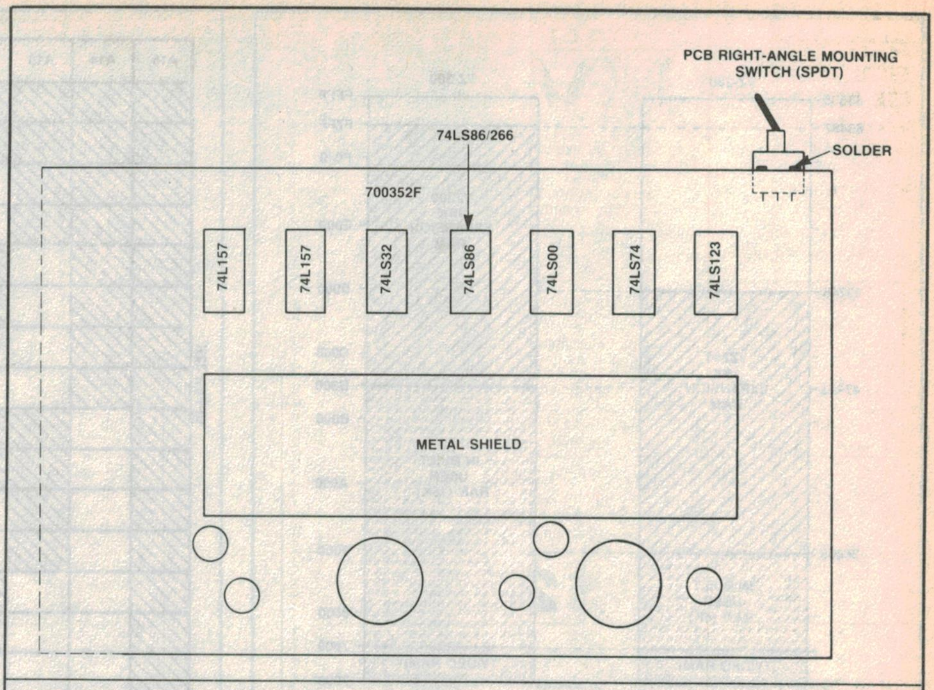

Figure 4. Component-side view.

Carefully bend all the pins *except* pins 1,2,7,12 and 14 on the 74LS00 at right angles to their original positions and carefully solder 'piggy-back' style pins 1,2,7,12 and 14 of the 74LS00 to pins 1,2,7,12 and 14, respectively, of the 74LS32.

Join pins 3, 4 and 5 on the 74LS00 together and solder them. Also join pins 9,10 and 11 together and solder: Join pin 6 to pin 13 using flexible multi-strand wire, then join pin 8 of the 74LS00 to the remaining side of the switch to give the VZ300 mode.

Testing

That completes the hardware modification and the module is now ready for testing in your VZ300. Go over the modification carefully, making sure the wiring is correct and look out for solder bridges. With the power off, plug in the modified module, switch to VZ200 mode, and turn on the power to the computer. Type in the following

```
PRINT PEEK(30897) +
256*PEEK(30898) <RETURN>
```

If everything is OK, the response should be

```
53247
```

Now switch off the power to the computer, switch to the VZ300 mode and then switch the power back on. Type in the above line again. This time the response should be

```
63487
```

If any of the above two responses are not obtained, then switch off immediately, and re-check the modification looking for wiring mistakes or solder bridges.

By comparing these two responses with the response obtained without an expansion module plugged into the VZ300, it can be seen that the modification enables all 16K (16384) bytes of the expansion memory instead of only 6K (6166) bytes of the standard VZ200 module. That is:

- top of memory VZ300 alone = 47103;
- top of memory VZ300 + unmodified module = 53247 (6144 bytes extra);
- top of memory VZ300 + modified module = 63487 (16384 bytes extra).

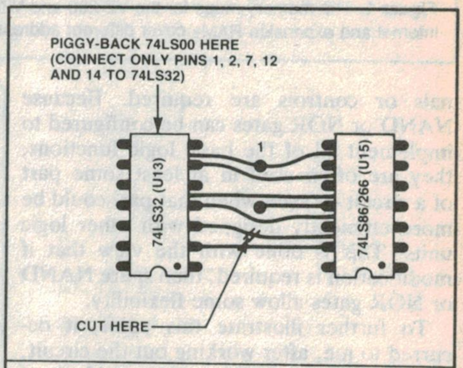

Figure 5. A closer view of the component side and directions.

Extra modifications

Before the module is re-assembled, an extra modification can be made, as mentioned earlier. This is to remap the expansion module to the top of addressable memory for reasons outlined before. This involves adding an extra change-over switch as shown in Figure 3.

Note that any of the switch connection positions can be replaced by direct wiring if operation in that mode is permanently required.

Happy Hacking!!! ●

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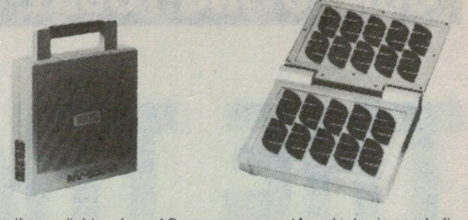

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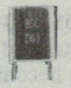
SMALL  HC/49u  HC/50u LARGE  HC/51u  HC/48u

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THE TRANSPORTABLE INTERFACE PERIPHERAL (TIP)

Investigations by the CSIRO's Alex Bendeli have led to the creation of a unique mass storage device capable of storing data from virtually every computer on the market today. It's too valuable an idea to languish in the corridors of the CSIRO so it's being offered to private enterprise — maybe you — for marketing under licence.

Alex Bendeli

WITH THE PROLIFERATION of computer brands the task of transferring software and data has become more and more difficult. One of the earlier *de facto* standards for data interchange was the SSSD 8" byte/sector IBM 3270 format. However with the advent of double density, double sided 5¼" and 3½" diskettes, density and format variations make it just about impossible to directly and easily transfer data. When data format conversion software is available, the media may be incompatible. The early standard is rapidly being replaced by the 'IBM compatible' (again!).

Out of this jungle there appears to be one way of transferring data between computers and this is through the RS232 lines. In fact modems are just long extensions of RS232 lines. Data transfer through most modems is normally limited to between 300 and 1200 baud and a modem is required at each end. Transfer of five pages of text at 1200 baud takes three minutes (about 4300 characters per A4 page).

The transportable interfacing peripheral (TIP) reviewed here was designed for the situation where several 'imcompatible' computers have no communication lines between them. It is not meant to be a replacement for modems. Its main purpose is to receive serial data from a computer at the highest baud rate, store the data in a non-volatile medium (bubble memory) and after transport to the receiving computer (or peripheral, eg plotter, printer, punch, CNC machine, typesetter etc), transmit the data to the latter. Because of its versatility and ease of use, several fields of application are envisaged: text file transfer, data logging, replacement of paper tape, and transfer from home computer to office or central computer.

Bubble memory

Although bubble memories have been available since 1979, they have been slow to find their way into equipment because of the limited number of manufacturers and initial manufacturing yield problems. Originally, at least three semiconductor manufacturers entered the magnetic bubble memory (MBM) field. However Intel seems to be the only one which has kept its commitment in that field. In fact its consistent MBM product range has led to dramatic price reductions over the last few years. There is also a Japanese source (Fujitsu) but the products are not necessarily interchangeable.

Good easy-to-read references on bubbles are the Intel publications *A Primer on Magnetic Bubbles* and the *Memory Components Handbook*. The latter is normally issued with the Intel MBM kit. (Figure 1 is reproduced here by permission of Intel Australia.)

The medium in which the magnetic domains shown in Figure 1 are formed is extremely thin (25 micrometres). When the material is subjected to a fixed magnetic bias field, the domains shrink and eventually take the shape of small cylinders approximately 3 micrometres in diameter. When viewed from above, they resemble

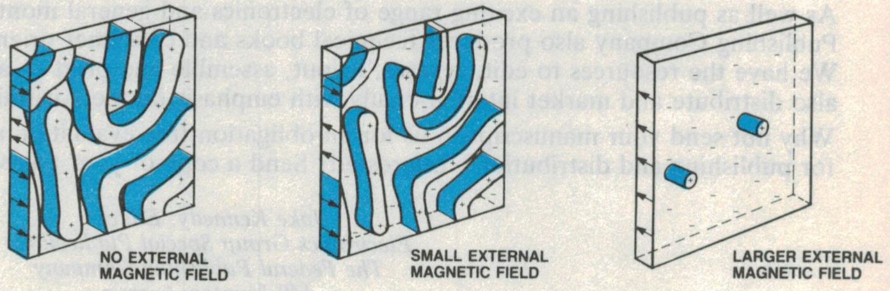
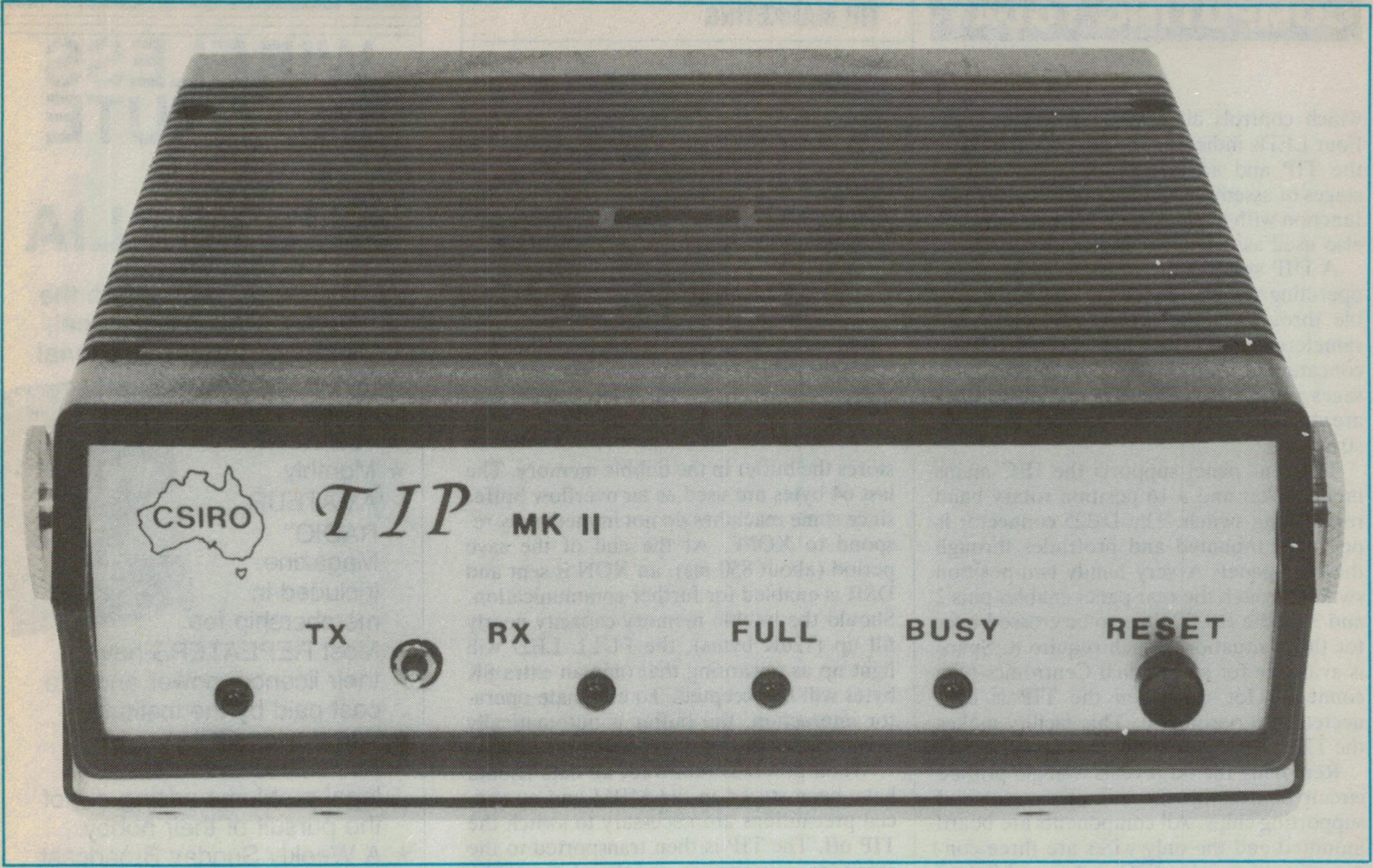


Figure 1. Magnetic domains in thin film under increasing magnetic bias field.



'bubbles'. Increasing the magnetic field strength beyond a certain value shrinks and 'destroys' the bubbles. In fact, the domain polarity is reoriented in the opposite direction and ceases to be a bubble. When another control magnetic field gradient is superimposed over the bias field, the bubbles move from a region of lesser magnetic field strength to a region of greater magnetic field strength. This is achieved by a fixed asymmetric magnetic film pattern overlaid on the domains. Application of control rotating magnetic fields generated by fixed coils wound over the magnetic film and domain layers causes the bubbles to propagate along pre-defined paths past sensors and bubble generators. The sensor consists of a magneto-resistive bridge whose impedance changes whenever a bubble passes under it. Presence or abundance of a bubble represents a data 1 or 0.

Bubble memories belong to the class of magnetic storage media which have the inherent property of preserving data when the power is removed. To place the bubble in perspective, consider the following forms of magnetic data storage:

(a) **Core memories:** Data is stored as a direction of magnetisation of the cores. In this case the cores and the data are stationary. Data selection is achieved by energising appropriate address lines. Unlike the following types which read data in block form, core memories can read a single byte at a time.

(b) **Tape:** Data is stored as a magnetising signal on the tape. The medium moves past a head and addressing is not normally carried out except for header, title and end of block recognition.

(c) **Disk:** This is very much akin to tape where data is stored as a magnetising signal on the disk medium. The data is stationary and the medium moves the data past a head. Address selection is carried out by appropriately moving the head to a given track and waiting until a specific sector passes under the head.

(d) **Bubble memory:** The data is stored as a presence or absence of a magnetic bubble in a magnetic substrate (medium). The medium is fixed but the data 'moves' past a fixed sensor under the control of rotating magnetic fields. Addressing is achieved by waiting until the selected page of data (64 bytes) passes under the sensor head. Hence there is a minimum access time (similar to disk drives) of about 41 ms + 7.5 ms/page. The average data transfer rate is about 8.5K bytes/s.

The device

The CSIRO-developed peripheral was designed with emphasis on the non-volatility of data when the power is removed, reliability due to lack of moving mechanical parts, immunity to dust and other particulate matter and the use of RS232 for data transfer. The unit measures 210 x 175 x 55 mm and weighs 1.5 kg.

The front panel (see photo) carries the RESET switch and a RX/TX mode switch

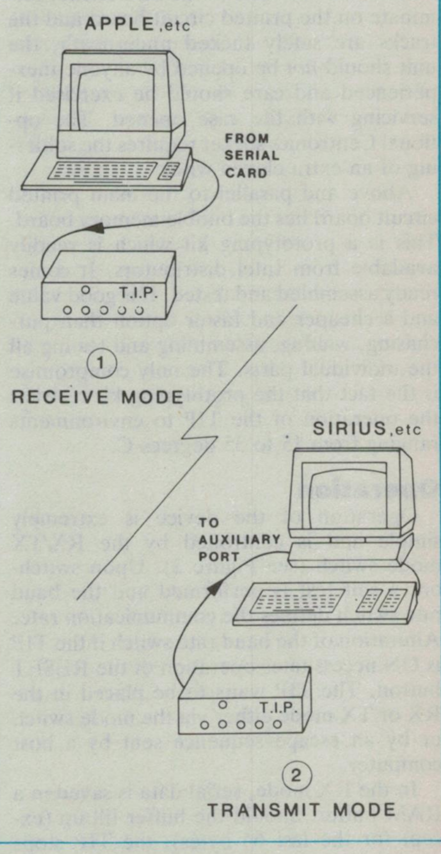


Figure 2. Operation of the TIP.

which controls all operations of the TIP. Four LEDs indicate the various activities of the TIP and are used during the various stages of assembly and manufacture. In conjunction with a table in the manual, they are also used as diagnostic indicators.

A DIP switch which defines some of the operating parameters of the TIP is accessible through the bottom cover. These parameters include a test mode, the facility to concatenate ASCII files, diagnostic messages output etc. The DIP switch settings are defined on a label at the rear of the instrument.

The rear panel supports the IEC mains input socket and a 16 position rotary baud rate setting switch. The DB25 connector is pc board mounted and protrudes through the rear panel. A very handy two-position switch through the rear panel enables pins 2 and 3 on the RS232 lines to be crossed-over for those situations which require it. Space is available for an optional Centronics-type connector for use when the TIP is connected to a peripheral. This facility makes the TIP a handy serial-to-parallel converter.

Removing the lid reveals a single printed circuit board with the microprocessor and supporting chips. All components are board mounted and the only wires are three connected to the mains IEC socket and five to the baud rate switch. Although the 240 Vac wires from the back of the IEC socket terminate on the printed circuit board and the tracks are safely tucked underneath, the unit should *not* be opened by anyone inexperienced and care should be exercised if servicing with the case opened. The optional Centronics socket requires the soldering of an extra eleven wires.

Above and parallel to the main printed circuit board lies the bubble memory board. This is a prototyping kit which is readily available from Intel distributors. It comes ready assembled and tested. It is good value and a cheaper and faster option than purchasing, waiting, assembling and testing all the individual parts. The only compromise is the fact that the prototyping kit restricts the operation of the TIP to environments ranging from 15 to 35 degrees C.

Operation

Operation of the device is extremely simple and is controlled by the RX/TX mode switch (see Figure 2). Upon switch-on, a self test is performed and the baud rate switch defines the communication rate. Alteration of the baud rate switch if the TIP is ON necessitates operation of the RESET button. The TIP waits to be placed in the RX or TX mode either via the mode switch or by an escape sequence sent by a host computer.

In the RX mode, serial data is saved in a RAM buffer. Should the buffer fill up (except for the last 64 bytes), the TIP stops communications via XOFF and DSR, and stores the buffer in the bubble memory. The last 64 bytes are used as an overflow buffer since some machines do not immediately respond to XOFF. At the end of the save period (about 850 ms), an XON is sent and DSR is enabled for further communication. Should the bubble memory capacity nearly fill up (120K bytes), the FULL LED will light up as a warning that only an extra 8K bytes will be accepted. To eliminate operator interaction, the buffer is automatically saved at the end of the transfer process.

When power is removed, all data should have been stored in the MBM and no special precautions are necessary to switch the TIP off. The TIP is then transported to the receiving computer or peripheral, set to the appropriate baud rate, switched on and the mode switch set to TX after initialising a communication software in the host. If several ASCII files were dumped into the TIP, the concatenation feature allows the TIP to search and stop at the end of each file before proceeding to the next one. In this way several files can be downloaded. Since data is always in the MBM, operation of the TX switch after the end of a transfer will re-enable a second transfer and several copies of the same data can be dumped if necessary.

Any machine supporting a serial RS232 line should be capable of using the TIP. In CP/M machines, transfer is performed using the PIP command (already successfully with Apple, Sirius, Kookaburra, OKI, VAX, HP9845, HP86B, Microbee, Data General NOVA). Other computers require appropriate software.

Manual

A very detailed manual describes the operation of the TIP both in terms of hardware and software. A comprehensive assembly and testing procedure is given along with a parts list and a cost estimate. All parts are readily available. The single most expensive item is of course the bubble memory prototyping kit, at approximately $350 RRP. While the cost is similar to a disk drive with controller it is a far more reliable alternative. For a one-off unit, total cost is approximately $550 RRP in parts plus about two hours to assemble the unit by experienced staff. ●

TIP MARKETING

The government-run CSIRO is staffed by some very able scientists whose job it is to investigate various natural phenomena. From time to time they have particular problems that cannot be solved by buying off-the-shelf products. One such problem and its solution is described here by the CSIRO's Alex Bendeli.

The CSIRO requires someone to market and manufacture the TIP device under licence. The licence fee will be a nominal amount only. If you are an Australian citizen, here is a unique opportunity to benefit from the design prowess of your government research organisation.

So, if you see yourself as the founder of a great electronics empire, or even a little one, call Alex Bendeli or Dr R. McCreadie on (02)467-6211.

Ups and downs of Aussat

In contrast to the launch of the first satellite in August, Aussat 2 went up without any fuss at all last November. Mission 61B lifted off from the Kennedy Space flight centre a few milliseconds after 1129 Sydney time, rolled over and disappeared into the night sky over the South Atlantic.

It was one of the more spectacular launches of recent time. It occurred at 7.30 in the evening, local time, and the glare of the rockets was visible all over the south eastern US, the Caribbean and Cuba. In contrast to earlier launches, there was almost no cloud in the sky.

Mission 61B was flown by the Atlantis, the latest and final orbiter to be built for the US government by Rockwell Aerospace. It was the first commercial mission for Atlantis, which was carrying Morelos B for Mexico, Aussat 2 and Satcom KU1 for a private US network.

One of the visual highlights of the launch was the separation of the two booster rockets on the side of the main tank. The manoeuvre was clearly visible through TV cameras that monitored the launch. The boosters are designed to separate from the main vehicle a minute or so after launch and then drift down into the sea under parachutes, where they are recovered and reused. The only part of the shuttle package that is not recovered is the main propellant tank. Although it is the most dominant part of the craft at launch, it consists of very little except rocket fuel.

Some consolation for Australians dismayed at the pathetic local content in the first generation Aussats is that both the Hughes HS 376 craft on board, Morelos and Aussat, carried Australian made wiring harnesses. These are manufactured by STC at Liverpool near Sydney, and have already flown in Morelos A, a similar Hughes craft launched for Mexico in June 85.

The final planned launch in this Aussat series is scheduled to fly atop the European Ariane rocket in June. Originally Aussat 3 was designated a ground standby, but demand has forced Aussat to bring it into service. In fact, Aussat's Graham Gossewinkel, at a post launch press conference, suggested that a distinct possibility exists for a fourth Aussat to fly.

Aussat 4 is currently being built at the Hughes facility at El Segundo, a suburb of Los Angeles. It was planned as a mission backup — if anything goes wrong with a launch or with one of the spacecraft in orbit, then Aussat 4 will replace it. However, having built it, and incurred all the associated costs, Aussat would be delighted if demand rose to the point where it could justify the launch costs.

According to Gossewinkel, three quarters of all the transponder space on the three planned Aussats has now been allocated. In spite of the last minute chaos surrounding the introduction of satellites to Australia, it seems that the business, communications and electronics industries are finally getting behind the idea of a satellite.

Another source of increased demand has been caused by the New Zealand government finally deciding in favour of satellites. The NZPO will be the first organisation to use Aussat for telephone traffic, the role for which it was originally intended. Also, New Zealand, like Australia, will be using the satellite for the reticulation of television signals. No direct broadcasting capacity is planned.

Extending even further the international role of Aussat, negotiations are in train for the use of Aussat in the South Pacific. New Guinea will get an entire transponder on Aussat 3, and the smaller South Pacific nations will also be served. However, it appears now that the Fiji TV service, originally intended via Aussat, will now be brought in by Frank Packer's TCN network direct from the US using Intelsat.

Increased activity in Costa Rica

The opening of a powerful new gospel station, the adding of an English session to Radio Reloj transmission and higher power for Radio Impacto are recent broadcasting advances in Costa Rica.

The Adventist World Radio established a station in Guatemala some years ago which operates with low power on both medium and shortwave, and has been heard in the South Pacific on 6090 kHz. The station has the call TGMUB and the slogan "Union Radio — AWR".

Adventist World Radio also purchased Radio Lira which operates in Costa Rica, and in the past two years has been upgrading the facilities. It has installed a 100 kW transmitter at a site 20 km from San Jose.

Using the slogan Radio Lira International, the New Adventist World Radio takes over the activites of Radio Lira; this long established broadcaster has in the past only operated on mediumwave 1540 kHz.

Broadcasts from Radio Lira International are expected to commence to North, Central and South America and the Caribbean. Programming will be in Spanish but there will be some broadcasts in English.

According to the station manager, David Gregory, Radio Lira International will be independent of the broadcasts of Radio Union in Guatemala though both stations will use the same interval signal.

A tentative schedule for the station is 0900-1300, 2200-0300 UTC using the 25 and 49 metre bands. According to Radio Nederland, the station's mailing address is PO Box 1171, in Arahua, Costa Rica.

Radio Reloj which operates on 4832 and 6006 kHz 24 hours a day, continues to receive mail from many parts of the world, and has recently introduced a mailbag session. This English broadcast is heard on Radio Reloj on some Sundays 0700-0800 UTC. The station is receiving between three and five letters per day from overseas listeners and this forms the basis of the international letterbox.

Radio Impacto which we reported when it first commenced operation on 6150 kHz some years ago has now increased the power of the shortwave transmitter from 20 to 50 kW. Radio Impacto formerly operated 24 hours a day, but now has a schedule of 1100-0600 UTC. The station has a political type of transmission and is against the Government of Nicaragua.

The studios are located in a house in the outer suburbs of San Jose and this is linked to the transmitters by VHF link. The transmitters are located outside San Jose and operate on 980 and 6150 kHz.

— Arthur Cushen

CLUB CALL

The recent Annual General Meeting of the **Townsville Amateur Radio Club** saw a total of 31 positions filled for the coming year. The only position not filled was that of Class Manager. Those interested in the positions and appointees or the club in general can contact Peter Renton VK4PV, PO Box 964, Townsville, Qld 4810.

Portable rf monitor

The newly-developed EB100 Miniport Receiver operates within the frequency range from 20 to 1000 MHz.

Frequency setting is made quasi-continuously either by means of a rotary knob (resolution 1 or 10 kHz) or via the keyboard.

Another alternative for frequency setting is to call up internal memory locations. This is achieved by means of a frequency scan between freely selectable start and stop frequencies with a channel spacing from 1 kHz to 9.9999 MHz. A maximum of 18 preselected frequencies may be set using the integrated memory scan, where one frequency is constantly set or n frequencies are scanned.

To complement the EB100, an active directional antenna, the HE100 allows rf signal sources in buildings, installations or electric systems to be located — especially useful in EMC tests and when tracing sources of interference.

The HE100 fulfils all requirements imposed on a modern, manual DF antenna such as a distinct directional radiation pattern, maximum-signal direction finding, handy size as well as low weight and suitability for vertical and horizontal polarisation. The power for the antenna electronics is supplied by a built-in nickel-cadmium battery, the useful life of which can be up to several weeks depending upon the operating mode.

KILOHERTZ COMMENT

ALASKA: Station KNLS the New Life station, at Anchor Point Alaska, has moved up to the 49 metre band for almost all of its transmissions up to March 1986. English is broadcast 1830-2130 UTC on 6035 kHz, Russian 0930-1200 UTC 6025 kHz; Chinese 1200-1330 UTC on 6030 kHz and 1330-1500 UTC on 6145 kHz; Russian 1500-1730 UTC, English 1730-2030 UTC on 7355 kHz. KNLS is operated by the World Christian Broadcasting Corporation and uses one 100 kW transmitter for broadcasts in English, Russian and Chinese (Mandarin). The mailing address is PO Box 473, Anchor Point Alaska 99556.

AUSTRALIA: The cancellation of the weekly transmission from Radio Australia to those wintering over in the Antarctic ends 30 years of a unique broadcasting service. Radio Australia's regular Friday broadcast for one hour was familiar to many shortwave listeners as a message service from relatives in Australia, to Australians based at Macquarie Island and in the Antarctic area.

The session consisted of mail readings/greetings and social news to those isolated in the far south, and during the hour long transmission which first commenced in 1955, hosts were many Radio Australia personalities including Keith Glover and Mary Adams.

During the 1960s the Shortwave Service of Radio New Zealand also conducted a weekly service on Sunday evenings for New Zealanders at McMurdo Base, but it was discontinued some 10 years ago. The discontinued service from Radio Australia is being replaced by satellite coverage when Australia's third satellite is launched, which will be received throughout the south west Pacific and down to Antarctica.

PAPUA NEW GUINEA: According to information from the National Broadcasting Commission of Papua New Guinea, a contract has been let to Japan for the installation of three 50 kW shortwave transmitters to be installed at a new transmitting site at Lae. The transmitters will operate on the present frequencies of 3925, 4890 and 9520 kHz from late this year.

The NBC is continuing to move stations from the 120 to the 90 metre band. There are now only two stations left to change frequency, the transmitters for Radio Enga and Radio Simbu. Radio Simbu on 2376 kHz is likely to move to 3355 kHz next year. Radio Enga on 2410 kHz will move to the 90 metre band which will then house the 19 provincial stations in Papua New Guinea.

Some frequency changes will have to be made and it is expected that those stations on even frequencies will move 5 kHz lower, so that there will be a 10 kHz separation between Papua New Guinea stations in the 90 metre band. The stations on 3220, 3260 and 3290 kHz will probably drop 5 kHz in frequency.

Signals on the 90 metre band at present are heard with network news in English at 0900 and relayed from Port Moresby, while at 1000 UTC news in Pidgin is also relayed by many stations.

This item was contributed by Arthur Cushen, 212 Earn St, Invercargill, New Zealand, who would be pleased to supply additional information on medium and shortwave listening. All times quoted are UTC (GMT) which is 10 hours behind Australian Eastern Standard Time; areas observing Daylight Time should add a further hour to these schedules.

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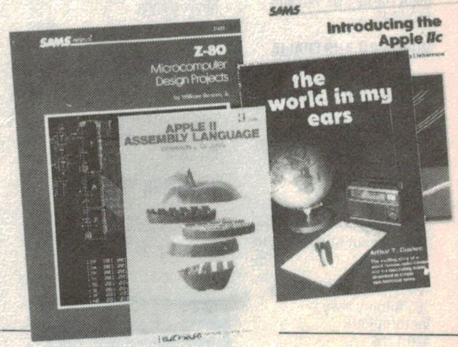

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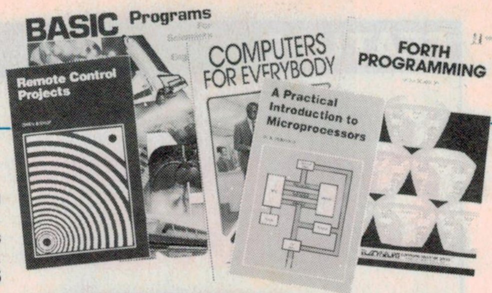

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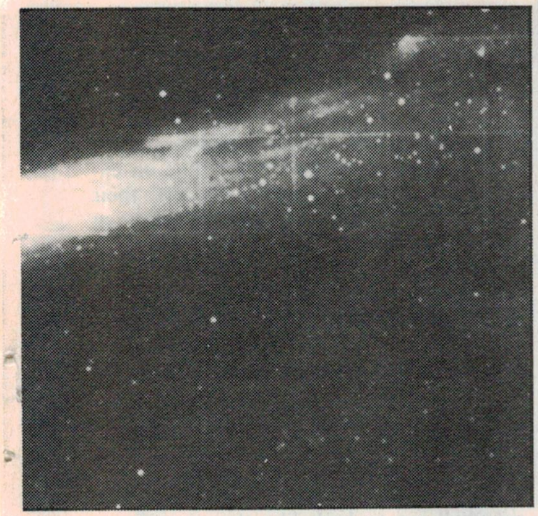
ETI READER SERVICE 146

COMET HALLEY

For most of us the next couple of months provides a once-in-a-lifetime opportunity to see this famous comet. ETI visited Australia's Siding Springs Observatory for a preview and to seek expert opinion about the event.

Jon Fairall



THE COMET IS coming back. Since 1948 it has been falling slowly inward towards its appointment with the sun. It has been doing the same thing for at least as long as there have been civilised men and women on this planet.

For most of that time it has caused panic as it flared briefly in the skies of Earth. Only on its last four visits has it been predicted, only on its last visit was it photographed. Halley's Comet marks both the generations of men and their progress.

In the visit of 1986, Halley's Comet will be probed, tested studied and examined as never before. Many of the tests would have been unthinkable the last time around, some of them even unimaginable. But as on every visit the comet has ever made, it will still be an occasion for the Wise Men to examine their bones, and tell a wondering audience a story.

The Oort cloud

A problem has lurked around the back door of modern cosmology for the better part of this century. Briefly it runs like this . . . Either the universe expands forever, or it oscillates. If it expands forever, then slowly, over eons, the galaxies we see today fleeing from us will one day fade away to nothing, and we will be alone in space. The time scale here is rather large so don't hold your breath.

But if the universe oscillates then slowly we will see the galaxies stop their mad rush away from us. The red shift will become blue and the universe will coalesce into a soup of matter and energy of unimaginable density. Then the whole process will start again.

In theory we can tell the difference between these two models of the universe by asking the question: are the galaxies we see today moving away from us at greater than the escape velocity of the universe? If they are, then nothing will hold them back and the universe will expand forever. If not, then one day the galaxies must stop, must fall, and descendants of the human race, whatever they look like, will have rather a large problem. The analogy with a rocket here on Earth is perfect. If it reaches escape velocity it flies. If it doesn't, then fall it must.

Escape velocity, the speed one body needs to escape the gravitational pull of another, depends wholly on mass. So cosmologists have spent a great deal of time trying to estimate the mass of galaxies. There are two ways to do it. One is to look at the orbital motions of the galaxies as they interact with each other. The other is to look at the galaxies themselves, and estimate, from the number of stars and dust clouds visible, how much they weigh.

The problem is that the two methods disagree, and not by a little. In fact the accepted difference between the two seems to be about 80 per cent. In the nature of the case there are all sorts of explanations: our understanding of large scale orbital dynamics is wrong; our methods of counting stars and their masses are wrong; and so on, with increasing degrees of sophistication.

Another explanation is that the discrepancy is real. The problem is resolved by postulating hidden mass. The first person to seriously introduce the idea of dark mass in the universe was Jan Oort.

According to Oort, who for many years held sway as the grand old man of Dutch astronomy, the space between the stars is populated by aggregations of space junk; clumps of dust grains, water ice and the occasional metal atom. They range in size from just a few micrometres up to many kilometres in diameter, from grains through boulders to mountains.

In a paper published in 1951, Oort argued that "the sun must be surrounded by a vast spherical swarm of comets with an outer radius of about 2.3 light years". This reservoir of cosmic junk is the so-called "Oort cloud". According to Oort, such a cloud was a natural leftover from stella formation, and every star would have one.

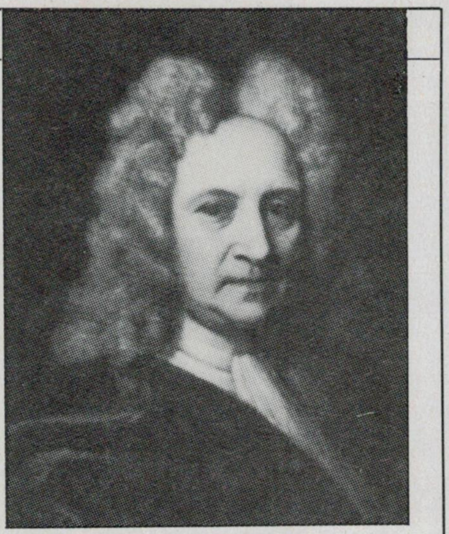
Its mass was calculated to be about one-tenth of a solar mass. On its own, that's nowhere near enough to fulfill the need for hidden mass in the universe, but nevertheless the Oort cloud makes the idea of dark mass scientifically respectable.

And it gives us two wonderful reasons for believing that comets are important. One is that the material of comets may be the most common state of matter in the universe, in which case the flyby of a comet is our only chance to study this state. The other is that comets are the leftovers of our own creation. To find the garden of Eden, just catch a comet.

Comet physics

We know surprisingly little about comets. One of the reasons is a very practical one. ▶

EDMOND HALLEY



Edmond Halley (1666-1742) was the complete renaissance man. His range of interests beggars belief. During his life he was employed as a sea captain, editor of a learned journal, deputy head of the Royal Mint, diplomat and academic. He founded a marine salvage company based on a diving bell he had designed.

He is considered the founding father of geophysics, and his interest in the Earth sciences led him to survey the English Channel and do studies of trade winds and monsoons. He sailed the Atlantic in the sloop HM *Paramour*, and in spite of illness and mutiny, made maps of magnetic variation.

He made the first calculations of the age of the Earth using modern scientific methods. Arguing from the rate of evaporation and erosion, he used the salinity of the oceans to determine a figure reasonably close to modern estimates. He was also the first to take a barometer up a mountain and so come to an understanding of the concept of atmospheric pressure.

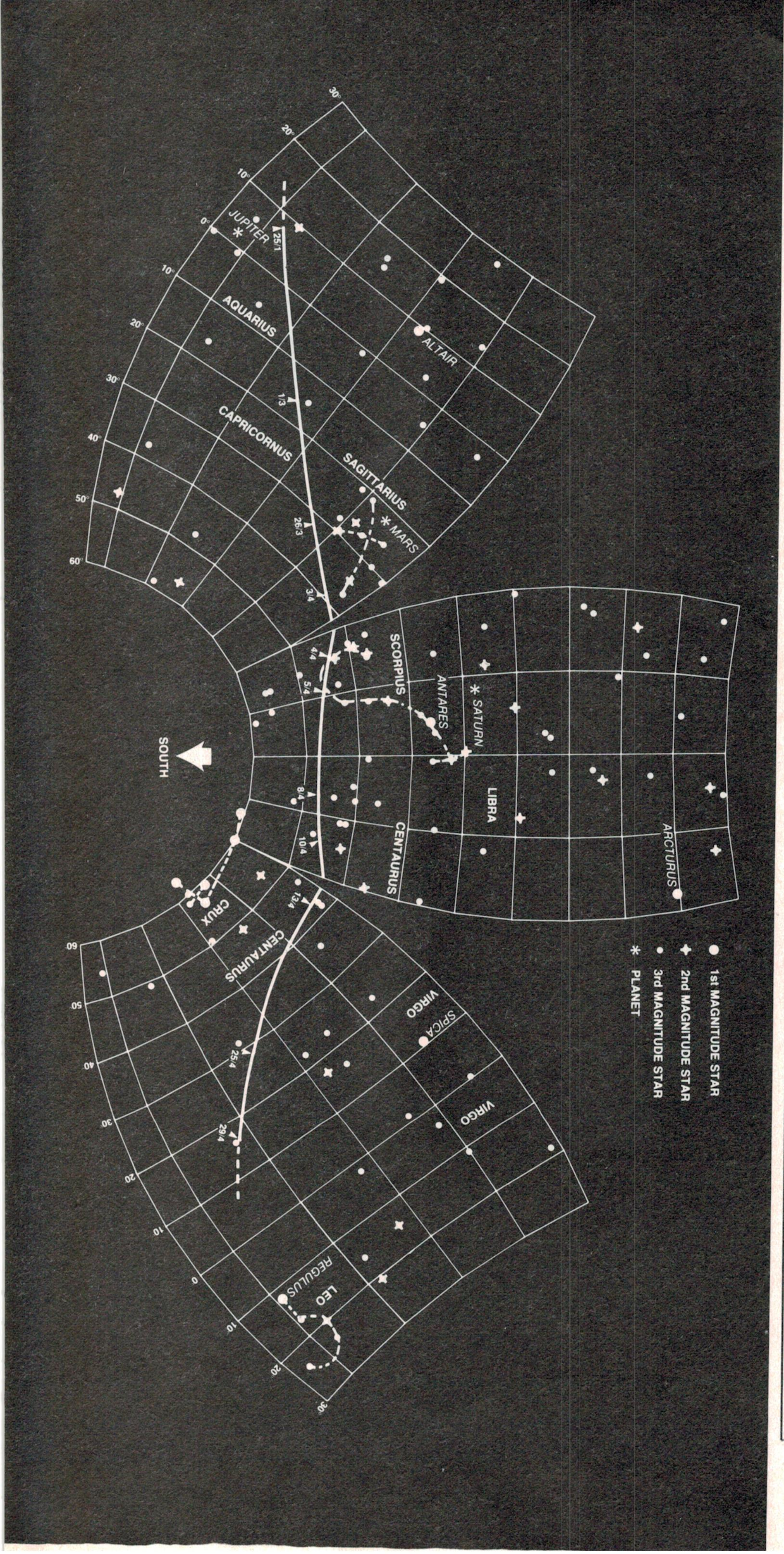
He was an able mathematician, and wrote papers on the roots of equations, the trajectories of missiles and optics. He was the first to develop mortality tables, on which the business of life insurance is based. He translated Latin mathematical texts into English.

He was, of course, pre-eminently an astronomer. At 19 he voyaged with the Astronomer Royal, Flamstead, to St Helena to look at the Southern stars. He was the first person to argue that the stars move slowly in relation to one another. He was one of the observers (along with Cook in Tahiti) who observed transits of the sun by Venus in order to determine the absolute scale of the solar system.

He was something of a wild lad too, partial to rum and women. A contemporary said of him: "He talks, swears and drinks like a sea captain." When he applied for a job at Oxford his former boss, Flamstead, warned that he would "corrupt ye youth of ye university with his lewd discourse". He was also an athiest, in a world governed by religious dogma, and to the Oxford dons he was about as welcome as a communist in the Pentagon.

His greatest claim to fame is that he convinced Isaac Newton to publish the laws of gravitation, worked out 20 years before. Almost incidentally, Halley used Newton's laws to calculate the path of all the bright comets of the previous few hundred years. Three of the comets, he noticed, followed the same orbit and were separated by an irregular period of about 70 years. Halley guaranteed himself immortality by claiming that there was only one comet.

But Halley, like most of us, was granted only one view of his comet. As a young man he saw it in 1682. He had been dead for 15 years when it finally reappeared.



Since they arrive so unpredictably, professional scientists competing for time on expensive equipment tend to exert their energy on objects that they know will be in the sky when they want to look. As a result comets tend to be found by amateurs, or serendipitously by professionals in search of some other object.

The present visit of Comet Halley is the first in which scientific instrumentation has been equal to the task of examining it closely. It is only the second return since photography was developed. It is time for confirming a few theories.

So, what is a comet? How does a dirty snowball get to look like the magnificent front picture? As the comet falls towards the sun, it begins to heat up. In the

HOW TO FIND HALLEY'S COMET

A comet follows an elliptical orbit around the sun (see main text) as does the Earth, so the way the comet appears to us on Earth is the result of the interaction of the two bodies. It also depends on the interaction of the comet with the sun.

On this trip Halley's Comet was first sighted on 16 October 1982 using the 200 inch telescope on Mt Palomar, California. It was at magnitude 24 and beyond the orbit of Saturn. During the early part of 1985 it drifted into line with the constellation of Orion, passing into Taurus late in the year. By November it was located close to the Philades. According to NASA, two of its scientists made the first naked eye sighting on the 13th, though a British team at the UK infrared telescope in Hawaii also made claim to the right.

However, the comet was at about magnitude 7 at this time, while the limit of naked eye vision is usually taken to be about magnitude 6. The writer observed the comet from Siding Springs Observatory during the same week (see picture), but with binoculars. Far be it for a humble journalist to dispute the claims of British or US astronomers, but I think we need a better grade of carrot juice in this country.

Comet Halley will reach perihelion on 9 February 1986 and begin to emerge from the morning twilight, gradually rising earlier and earlier throughout the month. By the beginning of March it will be rising at about midnight. During this period the Earth's orbit will be taking us rapidly towards the comet. The closest approach will occur on 11 April, when it will be visible all night. We may expect the best observing time during the periods in March and April when there is no moon in the sky. The comet will become a definite naked eye object, and should reach about magnitude 4.

It will be lost as the moon waxes during the latter part of April. By the time of the next new moon the comet will be too faint for unaided vision. For most of us, last contact will be during the lunar eclipse of 24 April.

Because of the way the comet's orbit and our own are related, the comet will approach and move away to the south. It only crosses the plane of the Earth's orbit for a brief period between November and May. Thus Northern Hemisphere viewing is constrained essentially to the times when the comet is at its least favourable.

vacuum of space, liquid water evaporates almost immediately so the ice sublimates (goes directly from a solid to a gaseous state). As it does so, the dust grains bound in the ice are also liberated.

This is not all surmise. Ultraviolet and radio observations of Comet Halley, made in September last year, when it was still beyond Mars, have demonstrated conclusively that comets are indeed 'dirty snowballs'. Observers have seen the telltale signs of hydroxil, a chemical given off during the breakdown of water in the presence of the sun's ultraviolet radiation. Radio astronomers at Nancay in France were the first to be able to put numbers on the breakdown rate. In August they announced that Comet Halley was losing 25,000 tonnes of ice a day. By 21 September, observations from the International Ultraviolet Explorer satellite showed that the sublimation rate had increased to 100,000 tonnes daily.

It's important to emphasise the word 'dirty'. The snowball is inhomogeneous, filled with foreign bodies and gas pockets of all kinds. This situation results in the surface heating at different rates, so that the comet nucleus fizzles and sparks. This behaviour was observed directly for the first time in October, when Heidi Hammel of the University of Hawaii took pictures of jets of material being shot out from the nucleus. The differential melting results in high speed jets flying out in random directions, and they can be strong enough to affect the comet orbit.

The result of this process of heating and sublimation is that the comet surrounds itself in a cloud of dust and gas, called the corona. The scale of the thing is impressive; the nucleus might be 10 kilometres across, the corona can be bigger than the sun. There are two immediate consequences. One is that since part of the nucleus is turned into the corona, and since there is no known mechanism to reverse the process, comets are temporary objects, destined to burn out after a few hundred returns to the sun.

Notwithstanding this, comets last a very long time; in fact most of the long-period comets leftover from the birth of the solar system are probably still with us. This seeming paradox is caused by the fact that the ▶

On the other hand, we in the Southern Hemisphere will have a front row seat. Not that our view will be all that spectacular, indeed our view of Halleys will be the worst for the last thousand years. Our closest point of approach will be 0.14 AU (an Astronomical Unit is one Earth-sun distance). On other approaches we have actually passed through the tail. Most professional astronomers advise that you must site yourself in a place where you can see the Milky Way clearly. For the most part this means getting out of the city. Ideally, do as the astronomers do, find a dark place, far from lights, and as high up as possible. Inland Australia is good. New Zealand, with its plethora of mountains far from city lights, should be ideal.

Unless you know your way around the sky a compass, the star map, a pair of binoculars and a torch are essential equipment for comet hunting. The best way to look at the night sky is to choose a warm night, find a comfortable spot and then lie flat on your back. Use the compass to orientate yourself so you know which way to point the map, then revolve the map until the Southern Cross correlates with its position in the sky. If possible, identify Mars and Saturn, and the bright star Antares in Scorpio. This will give you some feel for the scale of the map.

To get the best results, you need to make sure your eyes are night-adapted. This takes about fifteen to twenty minutes, so don't be disappointed if at first you can't see anything. Using the unshielded torch to look at the map will destroy your night vision so it's best to tape it up with red cellophane. With night-adapted eyes you won't need much light to see.

Is it worthwhile purchasing a telescope for the event? Probably not. The best instrument for comet hunting is a pair of good quality binoculars. You can purchase a decent pair for a reasonable price, whereas a good telescope will set you back quite a bit. A cheap telescope is simply not worth the trouble so don't bother with it.

Another problem with telescopes is that the field of view is narrow. This is a positive disadvantage when you are looking at a diffuse object like a comet. Another problem is that telescopes are difficult to handle. It takes time and patience to get the best from them. Binoculars are easy. All you need is a good support to hold them still.

PHOTOGRAPHING COMET HALLEY

There can be little doubt that the most rewarding part of the return of Halley's Comet is the chance to capture it on film. This is easier than it seems, provided you approach the matter correctly.

The first step is to get to the right place and identify the comet (see 'How to find Halley's Comet'). The need for darkness is even more essential than with visual observation.

The second step is to get yourself a decent camera. You need at least a good 35 mm with separate lenses, and then the longest lens you can afford. Many camera stores sell cheap 400 mm lenses for 35 mm cameras that probably don't have the greatest optical quality but will suffice for this job. However, if you have a 135 mm portrait lens, or even a standard 50 mm, you will get worthwhile results.

The third requirement is a good tripod. Your requirements here depend on how you intend to use the camera. If you intend to restrict yourself to exposures shorter than a minute, then with most normal lenses all you need is something to stop the camera moving; a robust photographer's tripod is ideal. A black card held in front of the lens while opening and closing the shutter is a useful accessory, as the camera shakes quite a bit during this operation.

If you are planning exposures longer than a minute, or if you are using long focal lengths, then some form of guiding is mandatory. This will allow you to compensate for the movement of the stars (or, rather, the Earth) over the time period of the exposure. An immediate problem is that while the shutter is open you cannot look through the camera itself.

Of course, if you have access to a proper motor driven astronomical mount the problem solves itself. These mounts will be available to the public at the Halley's Comet Village at Coonabarabran (see 'Getting the message out'). If you can't get there, you can jerryrig something. For instance, many cheap telescopes come with a cable drive which allows reasonably smooth traversing of the telescope. You can piggyback the camera on the telescope and then use the telescope to guide the camera manually. Another alternative would be to convert your camera mounting to an equatorial mount, complete with guide sight and some form of vibrationless drive. A good idea is to go into your local telescope shop and see how the professionals do it.

Fourth, you need some film. In choosing your film there are a number of choices to be made. Firstly, what about speed? Film speed is measured in ISO, DIN or ASA ratings. These you find on the side of the packet, and also on the camera somewhere to allow you to calibrate the light meter. The number here is a measure of how fast the film soaks up light. However, both the light meter and the film speed are virtually irrelevant in astronomical work because of the faintness of the target.

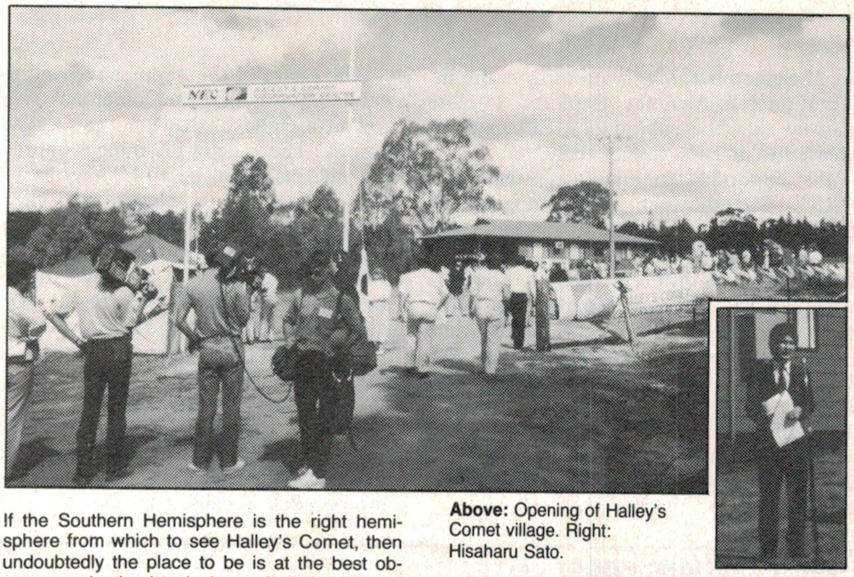
Far more important is grain size. Fast film has big grain, slow film has fine grain. Grain refers to the individual elements that make up the photographic emulsion, and obviously, the smaller these are, the sharper the finished photograph will appear. This is why professional photographers prefer to use slow film, even though it means pouring more light on to the subject to compensate for the poorer sensitivity of the film. It also means there are substantial advantages in using slow film in astrophotography. As a bonus, it is possible to find that the slower films actually become more sensitive at lower light levels.

Unless you are going to use a very sensitive lens, and going to stick to reasonably short exposures, it's better to use black and white film. Colour film is less sensitive to faint light than black and white, also there are problems associated with the colour balance of the film during long exposures. It's not uncommon to find yourself with a completely false colour image after a long exposure.

Whatever you choose in the way of lenses and film, the final indispensible requirement is plenty of patience and a minimal requirement for sleep. The idea is to pick a particular combination of lens and film and stick to it. Then try out different exposure lengths, starting on (say) ten seconds and increasing exposures by five second increments in order to see whether you are in the right ball park.

A final point. If you are getting the film commercially developed, mark it clearly as 'astronomical photographs'. There is nothing more disconcerting for the processor than to be confronted with a roll of black, and presumably blank, film. "Sorry" and a free roll of film will be small recompense if your shots of Halley's Comet get flushed down the drain.

GETTING THE MESSAGE OUT



Above: Opening of Halley's Comet village. Right: Hisaharu Sato.

If the Southern Hemisphere is the right hemisphere from which to see Halley's Comet, then undoubtedly the place to be is at the best observatory in the hemisphere. And that means Siding Springs, in the Warrumbungles of New South Wales.

The Japan Amateur Astronomical Association, under its president Hisaharu Sato, has set up a base just below the observatory. Here, amateur astronomers can use two 20 cm and one 30 cm telescopes for star gazing. There is also a sophisticated communications facility linked by satellite to Japan.

The centre is equipped with 10 NEC PC 9801 personal computers. Modems link them to OTC's Minerva system, then via Intellsat to the Halley's Comet Information Centre in Tokyo's Hibiya City, and to another centre in Osaka. Data on the comet's position, brightness and shape will be transmitted back to Japan in real time. The centre is also equipped with fax equipment to permit the transfer of graphic information back home.

The village is essentially Sato's brainchild. In real life he runs a coffee shop in Tokyo. He is a dedicated comet hunter in his spare time, whose ambition is to have a comet named after himself. His initial scheme was to have an international amateur presence at Siding Springs. But it appears things got a little bogged down in the negotiating stages and as a result it is only the Japanese who have come.

The visit has been sponsored by NEC, using the village as an example of the capability of its computers and communications (C and C) concept about which we are all going to hear more. There has also been substantial collaboration with scientists at Siding Springs, and with the local Coonabarabran council which is very interested in Mr Sato's plan to bring Japanese tourists up from the coastal fleshpots to peer into the telescopes, and stay in the local motels.

SUPERSTITION AND HALLEY'S COMET

Halley's Comet has been circling the sun for at least the last 2430 years. Don Yeomans in California and Tao Kiang in Ireland have both researched contemporary literature and have found references to appearances since 466 BC. They have done calculations of the orbit back to 1404 BC, but these can't be verified by eyewitness accounts.

Evidence of the 466 BC sighting consists of two ambiguous comments in Chinese and Greek annals. Appearances between 466 and 11 BC may have been recorded by the Chinese, but there are rather large uncertainties about the comet's orbit and in interpretation of the documents which make these claims somewhat weak.

From 11 BC onward we have unambiguous references to Comet Halley on every return. Each time it has been greeted as an omen, either of good or evil. Indeed, a look at the record makes a pretty good case for suggesting a relationship between the affairs of men and comet.

In 11 BC the comet shone on the death bed of Agrippa, Caesar of the Romans. In 451 AD it was in the sky when justice finally caught up with Attila the Hun. It blazed forth in 1066, when Harold, king of England, got one in the eye. It was there, without mercy, when Genghis Khan sacked Herat in Afghanistan. (Interesting to speculate what the Russians make of that.) In 1456 Pope Calixtus III excommunicated the comet for siding with the Turks.

In South America comets were considered messengers of the sun god, expressions of devine wrath. Halley's Comet and Pizarro arrived too close for comfort, and life was never the same again. In South Africa, Simon van der Stell watched the comet's appearance of 1682 as the Dutch East India company's colony struggled to survive. For both Dutchman and black man, a portent of future disaster.

In Australia, the stars were the visible manifestation of the sky people and comets were considered to be bundles of spears belonging to one with very strong magic. It was believed, however, that by pointing the atnongara stones at the evil one night after night, its evil would gradually diminish and fade away.

The return of 1682 was seen and recorded around the world. In England a young man watched it too, unaware, probably, of the link between his life and this messenger from the superstitious past. Because of Halley's work, the next return of the comet in 1759 was predictable, a victory for mathematics and the age of reason.

comet spends proportionally more of its time in the part of its orbit away from the sun than close to it. The speed of one body orbiting about another is directly related to the distance between them. The closer they are, the faster they move. This is true of satellites in orbit around the Earth, it's true of the Earth in its orbit around the sun and it's true of comets.

Of course, the Earth-sun distance changes only fractionally during a year so the effect is inconsequential. In the case of a comet, however, the effect is huge. In its 76 year orbit Comet Halley spends just a few months inside the orbit of the Earth, moving at about 54 km/s. It loiters for years at apogee, out beyond Neptune, moving at barely a kilometre per second. The effect is even more pronounced for comets that retreat further away.

The second consequence of the nucleus ejecting all this material, is the creation of the spectacular tail. There are actually two tails. One is the plasma or ion tail. It is a product of the interaction of the solar wind with the gases and charged particles of the corona. The solar wind is itself a stream of particles ejected from the sun and flying away in all directions.

The other type of tail is the dust tail. This is composed of dust particles from the corona and is swept back by the pressure of radiation on the particles. The idea that radiation, in particular sun light, can exert pressure on a particle may seem odd. It's not a very strong effect on Earth, but at the levels found in space close to the sun it becomes significant, especially when dealing with something as tenuous as a comet.

It goes without saying that the comet's tail is *extremely* tenuous. On occasions the Earth has actually passed right through it without any visible side effects at all. This all gives rise to another conclusion. The tail always points away from the sun. As a result when the comet is leaving the sun, as it is now, it is travelling tail first.

Orbits

That we see comets at all appears to be the result of chance. The comets in the Oort cloud are loosely bound to the sun's gravity, orbiting, as all things must, in orbits of greater or lesser eccentricity. But precisely because they are so loosely bound, it doesn't take much to change the orbit dramatically. A new alignment of distant stars, perhaps even a passing molecular cloud of gas — any slight change and the comets will scatter.

In the overwhelming majority of cases, the path of the snowball will be mildly affected and it will veer off on a new tack, perhaps to interact with some other star, perhaps on a new path around ours. Occasionally, a special event will occur. The comet will be deflected in towards the sun

itself, entering an orbit that takes it down on the sun and then back out to the periphery of the solar system.

Such comets are called long-period comets, for obvious reasons. They have orbits perhaps a thousand to a million years in length, and about 500 have so far been identified. In the nature of the case, however, most of those that exist will not be identified in the lifetime of our civilisation.

Permutations on this basic theme are possible. The comet may score a bull's eye, and actually hit the sun or one of the planets. Sometimes it doesn't quite hit a planet, but nevertheless interacts with it gravitationally. When that happens the comet may find itself robbed of the energy necessary to return whence it came. It may become gravitationally bound to the system, swinging back and forth in a suddenly shortened orbit that brings it back to the sun at regular intervals. There are about 100 of these short period comets with orbits less than a hundred years, of which Halleys is the most spectacular.

Space research

While the majority of comets might be unexpected, Comet Halley is anything but. Scientists have been waiting for its return for years, and tracking it since 1982. A small army of spacecraft has been sent out to gather as much information as possible.

The Japanese have sent three spacecraft. 'Planet A' carries a magnetometer, plasma analyser, spectrometer and ultra violet camera. The two smaller craft are called 'Tenema' and 'Sakigaki'.

The Russians have combined their latest Venus missions with a Comet Halley flyby. Each of its two Vega probes has released an orbiter to circle the planet before continuing on for a rendevous with the comet in March. Both will carry cameras and instruments for investigating UV and IR radiations from the corona and nucleus. They also have dust counting instruments on board to complement plasma analysers and magnetometers.

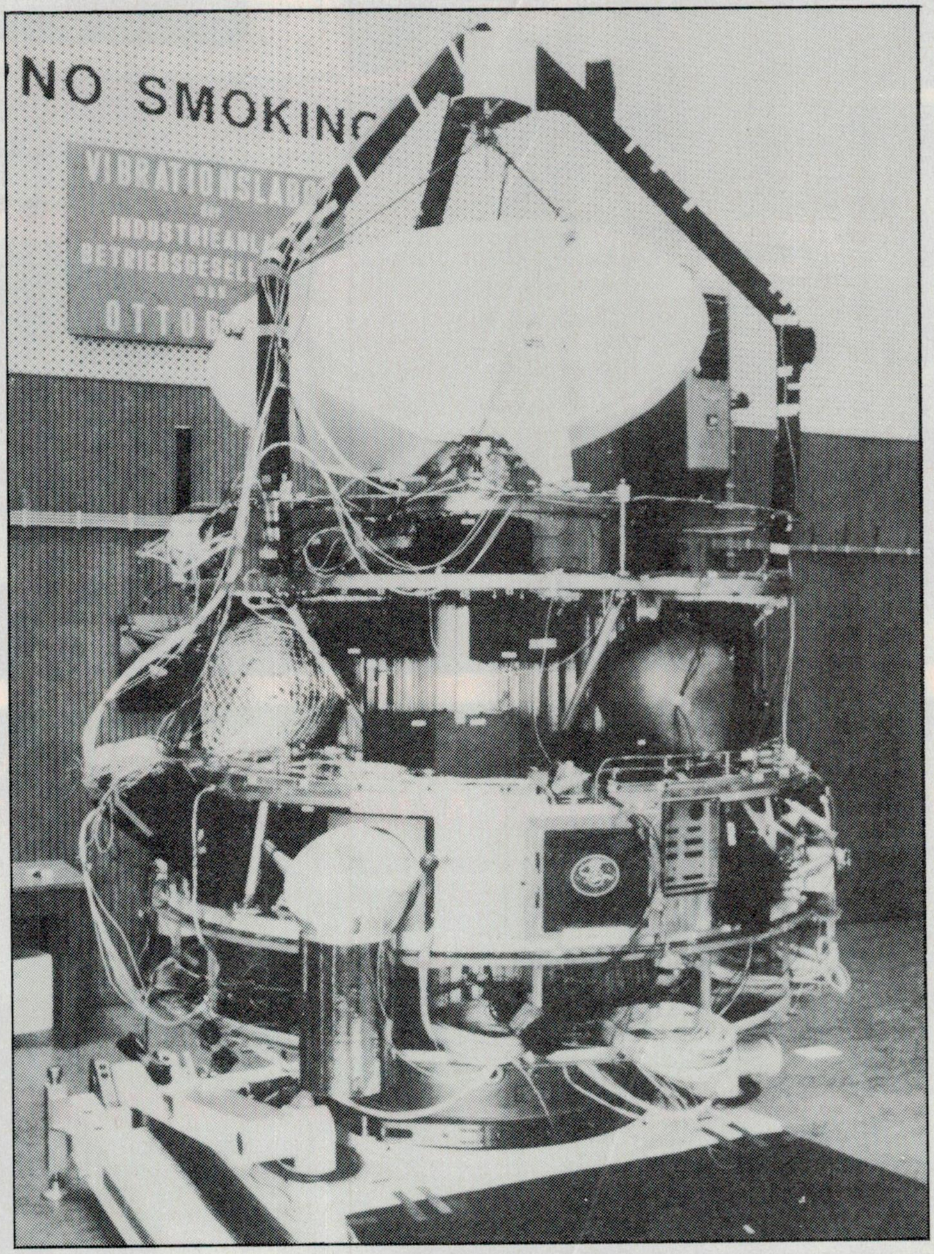
Probably the most ambitious of the spacecraft is the European Space Agency's Giotto, built for the most part by British Aerospace. As well as measuring the characteristics of dust and gas particles in the corona, Giotto has sensitive optical equipment with which it will try to photograph the nucleus of the comet.

This is more difficult than it sounds. The nucleus is very small so Giotto must get close to it. Unfortunately the encounter speed is about 70 km/s, so Giotto is designed to tolerate bombardment by the dust of the comet while transmitting its information rapidly back to Earth in case it is destroyed during the encounter. It is fitted with a heavy duty particle shield made of Kevlar, and the delicate antennae dish is located in the tail of the machine, hopefully safe from the dust storm that will be blowing outside.

As a prelude to the encounter, NASA sent its International Cometry Explorer (an obsolete Earth orbiting satellite) through the tail of comet Giacobini Zinner, which is also visiting us at this time. It survived a ride through the tail of the comet, but Giotto must survive inside the corona and that most likely will be more difficult.

If it seems odd that anyone should worry about the consequences of running into something as tenuous as the corona of a comet, it is worthwhile remembering that a single dust grain, at the speeds involved, has the same inertia as a light car travelling on a motorway.

There is a considerable amount of international co-operation being planned for the missions. It is expected that as the spacecraft hit the comet one after another, insights into the problems of getting close to it will be transmitted to other teams in the hope of making some last minute corrections. One point of concern is that ESA planners have not been able to identify the position of the nucleus precisely, so they look to the Russian Vega machines to give them fine pointing information. ●



ESA's Giotto, named after the renaissance painter Giotto whose famous nativity painting depicted the comet in the shepherd's sky.

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THERE'S MORE THAN TRANSISTORS . . .

Peter Phillips

The point of this series of articles on starting electronics is to offer practical advice on the use of components and circuits. In other words, to help you build things. A couple of things to be particularly aware of are how to recognise the devices you need and constraints on their use. For this, you don't always need the theory. That said, further to the world of solid state.

HAVE YOU EVER wondered what an SCR or a FET is? Perhaps you've pondered about PUTs, troubled over triacs, and then decided that all these terms seem meaningless. Be confused no more, they are all relatively simple devices, though they play a big part in electronics. In this article we look at the more commonly used of these devices — some of which you may encounter, be-

lieving them to be transistors. But, "it ain't necessarily so!" Such devices are discrete active components, 'discrete' because they are single devices rather than a part of an integrated circuit and 'active' because they need a power supply.

Two categories emerge in the study of these devices: the FET family and the thyristor group. Before looking at these however, one other common component must be treated in order to complete the subject of the pn junction started last month. That is the Zener diode.

The Zener diode

In part 10 of Starting Electronics the diode was discussed, introducing the concept of a device which allows unidirectional conduction of an electrical current. One property of the diode to be careful of is its PIV (peak inverse voltage rating), which if exceeded, causes reverse current and would result in the rapid demise of the device. The Zener diode, however, is a component designed to operate in this reverse conduction mode, given certain precautions. Named after Carl Zener, who studied the physics involving reverse conduction in a pn junction, these diodes are used mainly as voltage references.

Figure 1 shows the symbol and a typical circuit using a Zener diode as a voltage regulator. Note that a resistor is placed between the supply and the diode in order to limit the current in the diode to a safe value. A common application of the Zener is where the available supply voltage is either the wrong value or it varies beyond acceptable limits. The Zener diode and the resistor will work to maintain a constant voltage available to the load independently of either the supply voltage or the load current.

In principle, the Zener diode will conduct backwards, or from cathode to anode, when the voltage across these terminals exceeds the breakdown voltage of the device. The value of this voltage is a function of its manufacture and ranges from around 1.8 volts to over 200 volts. Providing the current does not exceed the rating of the diode, this reverse voltage will remain almost constant even though the current can vary from virtually zero to the maximum value.

Zener diodes are identified by two characteristics. The first is the Zener voltage, the other the power rating. This rating can vary from 300 milliwatts, up to as high as 100 watts. The maximum current the device can handle is found by dividing the power rating by the Zener voltage. The most common power ratings are 500 mW (or ½ watt) and 1 watt. The range of Zener voltages available is usually similar to that of resistor values, incrementing in steps to give a table of values that, allowing for a 5 per cent variation in value, covers the entire range. For example, just as there is an 8.2 ohm, or an 82 ohm resistor, so too the 8.2 volt, or 82 volt Zener diode is manufactured. Common voltage ratings are those less than 40 volts. If values higher than this range are required, 'stacking' suitable diodes is an option often employed.

Type numbers vary considerably, the BZ series identifies the Zener voltage with the last three characters in the form of, for example, 7V5 to indicate a 7.5 volt device. Another popular range is the 1N47XX family; the last two digits have no identifiable relationship to the Zener voltage. A 1N4737 is a 7.5 volt, 1 watt diode, the 1N4738 an 8.2 volt device. It is often difficult to differentiate between a conventional diode and a Zener, so it is wise to consult manufacturers' data sheets and the type number.

The FET

The field effect transistor, although conceived in the 1950s, didn't become useful as a device until several years later due to manufacturing difficulties. Constructed using one pn junction, the FET operates in a similar manner to the triode valve. Because of this, the FET has one very significant advantage over the transistor which is that it represents a virtual open circuit between its input terminals. The transistor lacks this feature, requiring the input signal to be able to handle a relatively low resistance often needing all sorts of fancy circuitry for the more delicate input transducers and increasing the complexity (and expense) of the circuit.

The transistor is referred to as a current operated device, in which the small base-emitter current controls the value of the larger collector-emitter current. The FET is voltage operated, whereby the *voltage* across the input terminals controls the current flowing in the device. Figure 2 shows the symbols used for the various types of FET currently manufactured. Like the transistor, two polarity types are made, the n and the p channel, incorporated in three basic FET varieties. These types are the ▶

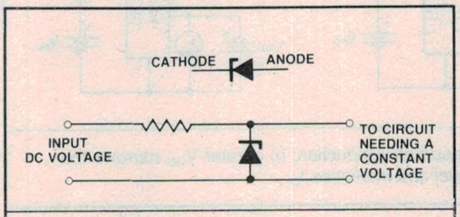
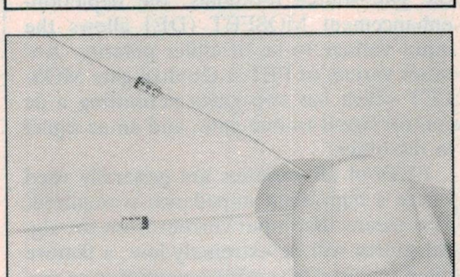
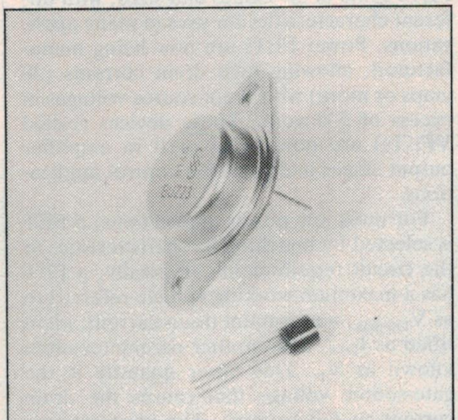


Figure 1. The Zener diode symbol and as used in a voltage regulating circuit.



A couple of Zeners.



FETs. The MOSFET is the large one above.

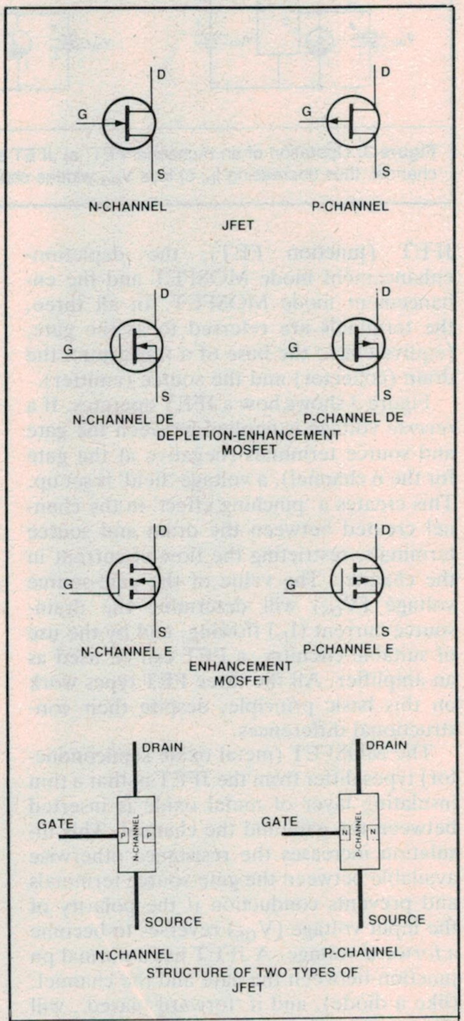
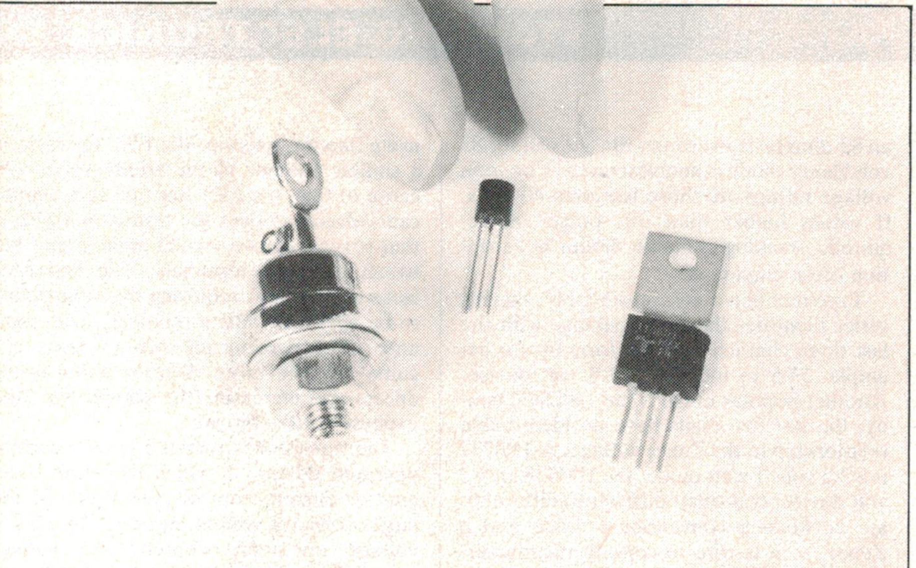


Figure 2. FET symbols.



SCRs in packages (from left to right) TO-48, TO-92 and TO-202.

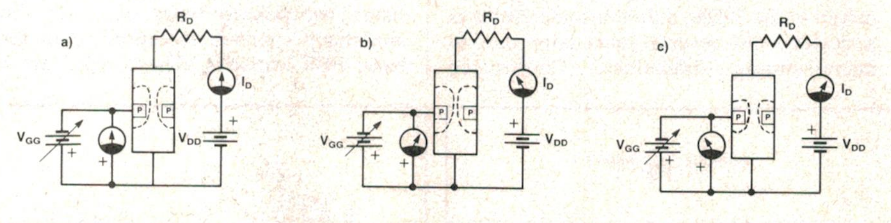


Figure 3. Operation of an n-channel FET; a) JFET biased for conduction; b) greater V_{GG} narrows the channel, thus decreasing I_D; c) less V_{GG} widens channel and increases I_D.

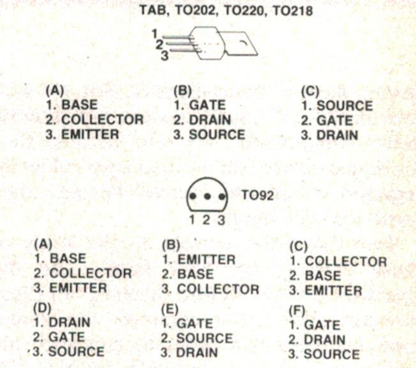


Figure 4. Some case outlines for FETs.

JFET (junction FET), the depletion-enhancement mode MOSFET and the enhancement mode MOSFET. In all three, the terminals are referred to as the gate, (equivalent to the base of a transistor), the drain (collector) and the source (emitter).

Figure 3 shows how a JFET operates. If a *reverse* voltage is applied between the gate and source terminals (negative at the gate for the n channel), a voltage 'field' is set up. This creates a 'pinching effect' in the channel created between the drain and source terminals, restricting the flow of current in the channel. The value of the gate-source voltage (V_{GS}) will determine the drain-source current (I_D) flowing, and by the use of suitable circuitry, a FET can be used as an amplifier. All the three FET types work on this basic principle, despite their constructional differences.

The MOSFET (metal oxide semiconductor) types differ from the JFET in that a thin insulating layer of metal oxide is inserted between the gate and the channel. This insulation increases the resistance otherwise available between the gate-source terminals and prevents conduction if the polarity of the input voltage (V_{GS}) reverses to become a *forward* voltage. A JFET has a normal pn junction between the gate and the channel, (like a diode), and if 'forward biased', will allow gate current to flow. The enhancement MOSFET doesn't have a 'channel' until a *forward* voltage is applied between the gate-source terminals; the depletion-enhancement MOSFET (DE) allows the input voltage to be of either polarity. Another variety of FET is the dual gate MOSFET which has two gates permitting a dc control signal to one gate, and an ac signal to the other.

FETs of all varieties are generally used where a high input impedance is required. This means that input current from the signal source will be extremely low, a feature often required in sensitive measuring or amplifying applications. Like the transistor, FETs come in all shapes and sizes, with different characteristics for uses in many applications. Power FETs are now being manufactured, allowing high drain currents (20 amps or more) with drain-source voltages in excess of 500 volts. These devices (called VFETs) are now being used in amplifier output stages and in power control applications.

For most low power applications, a FET is selected by matching its characteristics to the circuit requirements. Typically, a FET has a maximum working voltage referred to as V_{DGmax}, a maximum drain current, identified as I_{DSS}, and another parameter often known as V_P. This latter quantity is the gate-source voltage that causes the drain current to fall to zero. The characteristic I_{DSS} is the current flowing from drain to source when no input voltage is present between the gate-source terminals.

Another rating, variously known as Y_{FS}, or g_{fs}, gives a measure of the degree of control the gate voltage has over the drain current. The higher this figure, the greater the 'gain' of the FET. Like the transistor, the case outline will also be listed identifying the terminals. Some FETs allow the drain-source terminals to be reversed without affecting their operation. Figure 4 shows the case outlines of some common FET types. Note that the case outlines also have a lead identification for a transistor that may use the same package, illustrating how the same case type can contain different devices.

General purpose n channel JFETs include the 2N5457, the 2N5484; a common p channel device is the PN4360, or the 2N5460, each costing less than a dollar. MOSFETs cost slightly more and might range from one dollar up. Caution should be exercised in the handling of MOS devices as any static charge from the fingers, storage facility or soldering equipment can puncture the insulation, destroying the device. Wrapping a piece of fine wire so as to connect all the leads together is one precaution often used.

Thyristors

A generic term, the word thyristor refers to a family of devices characterised by an inherent switching action which is controllable by an external influence. These devices all have two possible states, either on or off. They are used to switch current in high power circuits, in timers, oscillators or similar low power applications. Like most solid state devices, at the base of these components is the pn junction; and they are packaged in cases similar to transistors and FETs.

To gain some appreciation as to how these devices operate, a short discussion on the Shockley diode is in order. Figure 5 shows the physical construction of the Shockley diode, which is comprised of four layers of doped silicon, creating three pn junctions. The effect of this construction is to create a two-transistor circuit as shown.

The anode is the terminal connected to the p type material, the cathode being connected to the n type.

If the anode is made positive to the cathode in a conventional diode an electrical current can flow, providing the voltage exceeds 0.6 volts. Reversing the polarity will not cause a current flow. In the Shockley diode a different set of operatives prevails. Applying a positive voltage to the anode will merely cause a small leakage current which will flow through the pnp transistor Q_1 into the base of the npn transistor Q_2. If the voltage is increased, eventually enough leakage current can flow to cause Q_2 to turn on, which then allows Q_1 to also turn on.

Thus the diode turns on, becoming a virtual short circuit between its two terminals. Naturally, steps must be taken to limit the current flowing through the device; usually a resistor is inserted between the supply and the diode. In principle therefore, the Shockley diode is turned on by applying a sufficiently high voltage across the device, with the anode made positive to the cathode. Once turned on, it can only be turned off by lowering the current flowing to a value that is unable to keep the two transistors on. Usually the current is interrupted causing it to drop to zero. Once this occurs, the diode can be turned on again by raising the voltage across it.

The switch-on voltage is called the *breakover* voltage; the minimum current to maintain conduction is referred to as the holding current, with a value usually less than 1 mA. Reversing the polarity of the voltage will not cause any conduction, unless the voltage is sufficient to cause the diode to breakdown and self destruct.

The diac

The diac (bilateral diode switch) is essentially two Shockley diodes in inverse parallel. Figure 6 should give the idea; this diagram also shows the circuit symbol. Used in low power applications, the diac will conduct in either direction once the breakover voltage is reached. It doesn't matter which way round the device is connected as switch-off is again achieved by lowering the diac's current to below the holding value.

There are two sorts of diacs: the symmetrical and the asymmetrical types. A symmetrical diac will break down at the same voltage either way round; the asymmetrical variety has different breakover voltages depending on polarity. Diacs are generally used to correct the switching of other thyristors (triacs and SCRs). The asymmetrical diac is often employed in light dimmer circuits. A typical symmetrical diac is the ST2, which looks like a diode and has a breakover voltage of around 30 volts. A common asymmetrical diac is the ST4, which has the appearance of a transistor with one leg removed. Voltages are approximately 12 volts one way, and 16 volts the other.

The SCR

The SCR (silicon-controlled rectifier) is a device designed to handle much higher currents than those thyristors discussed so far. As Figure 7 shows, this device is a Shockley diode with an extra connection, called the gate. The SCR will behave in the same way as the Shockley diode, in that it can be turned on by exceeding its forward breakover voltage, and must be turned off by reducing the current through it to a value below the holding current. However, the presence of the gate terminal allows another mode of control.

If the anode of the SCR is positive with respect to the cathode, but below the breakover voltage, the SCR can be turned on by applying a small positive voltage, around 0.6 V, between the gate and the cathode terminals. Once the SCR is conducting, the gate voltage can be removed and the device will remain on until the current is interrupted. This means that the SCR can be turned on by the application of a positive *pulse* of a few microseconds or so for the duration.

The SCR is used mainly where the load being controlled is supplied from an ac source. Because the polarity of the voltage is reversing (50 times per second for the mains), the current through an ac-supplied ▶

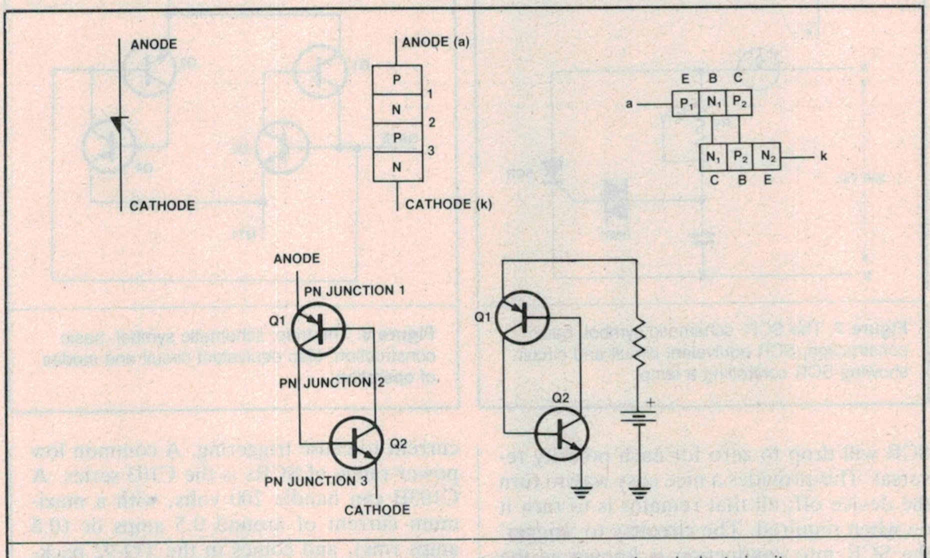


Figure 5. The Shockley diode: schematic symbol, basic construction and equivalent circuit.

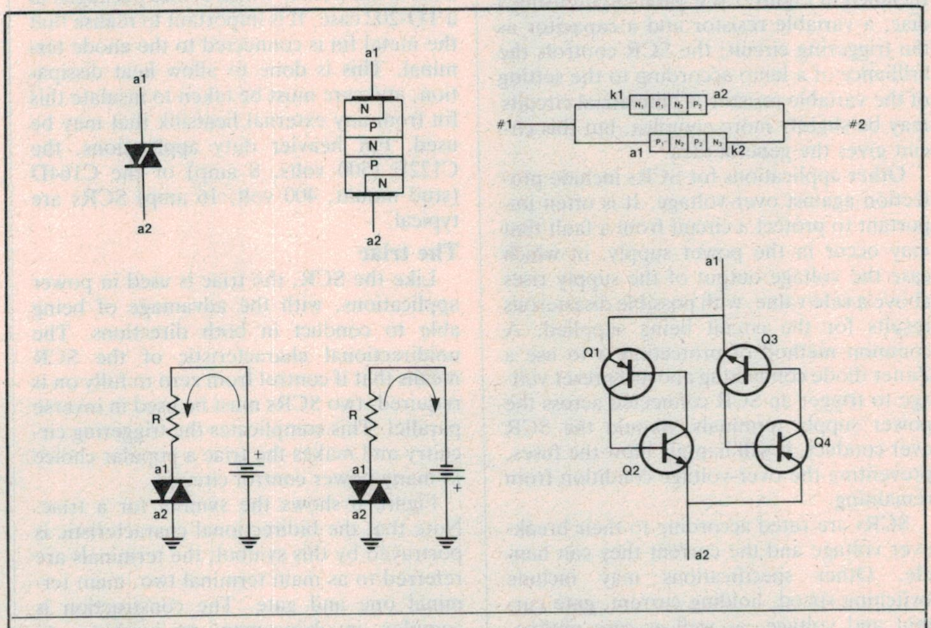


Figure 6. The diac: schematic symbol, basic construction, equivalent two-pnpn-Shockley diode representation, equivalent circuit and bias conditions.

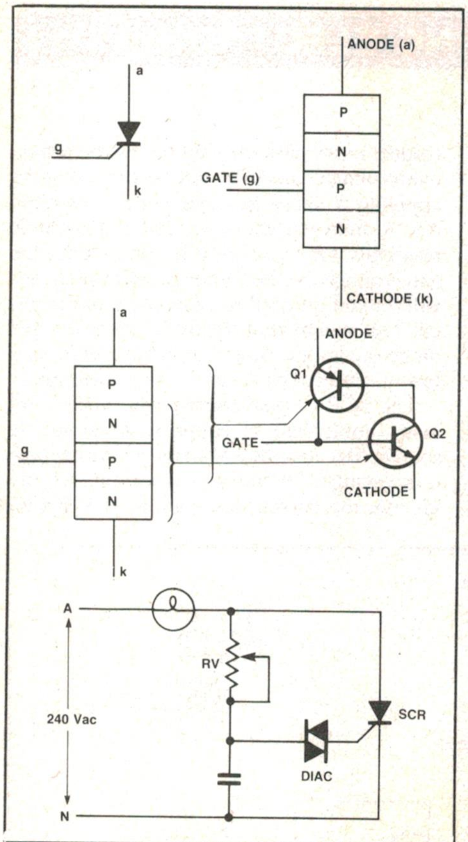


Figure 7. The SCR: schematic symbol, basic construction, SCR equivalent circuit and circuit showing SCR controlling a lamp.

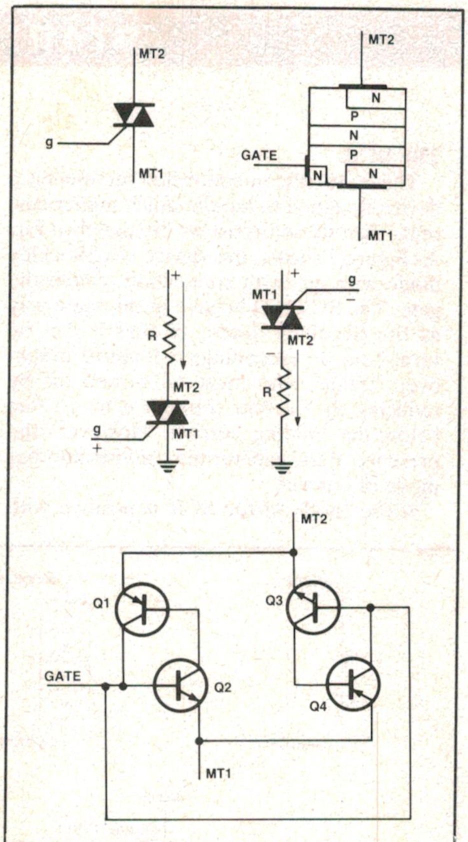
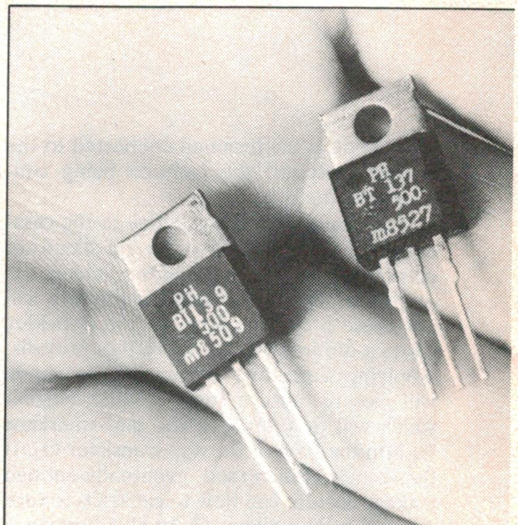


Figure 8. The triac: schematic symbol, basic construction, triac equivalent circuit and modes of operation.



Three triacs (all TO-220 packages) and an asymmetric diac.

SCR will drop to zero for each polarity reversal. This provides a nice easy way to turn the device off; all that remains is to turn it on when required. The circuitry to 'trigger' the SCR into conduction is known as the triggering circuit, and is often very simple. Included in Figure 7 is a basic circuit using a diac, a variable resistor and a capacitor as the triggering circuit; the SCR controls the brilliance of a lamp according to the setting of the variable resistor. Commercial circuits may be slightly more complex, but this circuit gives the general idea.

Other applications for SCRs include protection against over-voltage. It is often important to protect a circuit from a fault that may occur in the power supply, in which case the voltage output of the supply rises above a safe value, with possible disasterous results for the circuit being supplied. A common method of protection is to use a Zener diode conducting above a preset voltage to trigger an SCR connected across the power supply terminals. Should the SCR ever conduct, it will happily blow the fuses, preventing the over-voltage condition from remaining.

SCRs are rated according to their breakover voltage and the current they can handle. Other specifications may include switching speed, holding current, gate current and voltage, as well as case outline. Some SCRs are referred to as sensitive gate devices, meaning they need very little gate current to cause triggering. A common low power range of SCRs is the C103 series. A C103B can handle 200 volts, with a maximum current of around 0.5 amps dc (0.8 amps rms), and comes in the TO-92 package. A sensitive gate, 400 volt, 4 amp (rms) SCR is the C106D which comes packaged in a TO-202 case. It is important to realise that the metal fin is connected to the anode terminal. This is done to allow heat dissipation, and care must be taken to insulate this fin from any external heatsink that may be used. For heavier duty applications, the C122E (500 volts, 8 amp) or the C164D (stud mount, 400 volt, 16 amp) SCRs are typical.

The triac

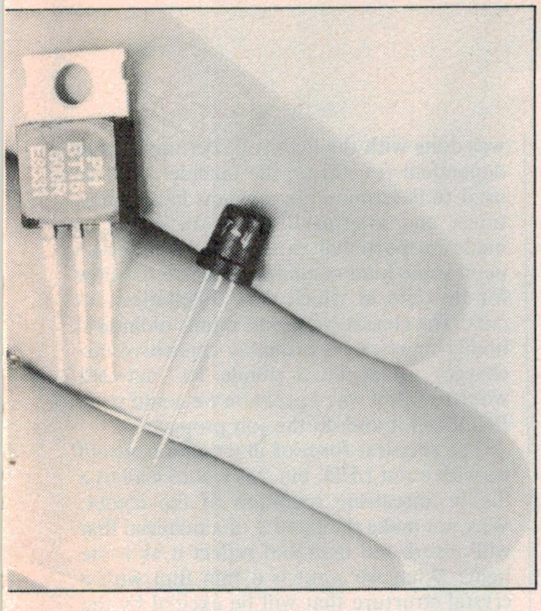
Like the SCR, the triac is used in power applications, with the advantage of being able to conduct in both directions. The unidirectional characteristic of the SCR means that if control from zero to fully on is required, two SCRs must be used in inverse parallel. This complicates the triggering circuitry and makes the triac a popular choice in many power control circuits.

Figure 8 shows the symbol for a triac. Note that the bidirectional characteristic is portrayed by this symbol; the terminals are referred to as main terminal two, main terminal one and gate. The construction is complex, involving many pn junctions, to effectively result in two back to back SCRs. The operation of the triac is similar to that of the SCR. Conduction results from a gate pulse and turns off only when the current falls below the device's holding current.

The triggering of a triac is interesting in that four modes of operation are possible, depending on the polarity of MT2 and MT1 and the polarity of the gate pulse. Although all four modes are possible, the triac is most sensitive in only two of these. These are when MT2 is positive, and the gate has a positive pulse applied, both with respect to MT1, and when MT2 and the gate are negative, again compared to MT1. The implication is that if a triac is connected with MT2 and MT1 reversed, erratic performance may result. Hence, correct terminal identification is necessary, or, failing this, trying the device in both ways.

Triacs are used extensively in light dimmers, motor speed controls, in domestic appliances (mixers, etc), as well as in industrial applications. Controller ICs are manufactured for use with triacs, allowing all kinds of special control methods. One useful control technique is to switch the triac on only when the voltage across it is small (near zero), and to allow the triac to remain on for say two cycles out of 10. Known as zero-crossing control, this method prevents radio frequency interference from occurring, a phenomenon which results whenever a high current is suddenly switched on. Where this type of control is not possible, special suppression circuitry should be employed.

As for the SCR, a wide range of triacs is manufactured. The SC141D and the SC146D are two common types. Both are packaged in a TO-220 case and have a 400 volt rating with, respectively, current capabilities of six amps and 10 amps. A 15 amp, 400 volt device is the SC151D while other types allow even higher currents and voltages. A point to note is that both the SCR and the triac are normally turned on by the gate pulse, but will also turn on if the voltage across them exceeds the breakover voltage. To avoid this, the device must be



selected to have a rating exceeding the applied voltage.

Another 'nasty' that will also trigger these components is the rate at which the applied voltage changes. All SCRs and triacs are given a dv/dt rating which refers to the *rate* at which the voltage across the device may change before triggering will occur. Usually given as a volts per microsecond value, triggering from exceeding this rating causes many problems, making circuit design using these thyristors more tricky than usual. In general, it is fair to point out that SCR/triac circuits are more difficult to design than most others; beginners should tread warily when using them. Many excellent treatises are available for help, such as the General Electric SCR manual which is comprehensive on these devices.

The UJT and the PUT

The UJT (unijunction transistor) is the simplest thyristor. Its construction and symbol are shown in Figure 9. Note carefully the difference between this symbol and that of the JFET. The terminals are known as base 2, base 1, and the emitter. The equivalent circuit is also shown, illustrating that the path between the base terminals is simply that of a resistor.

A pn junction (diode) is present between a tapping of the resistor and the emitter terminal. The voltage that will result at the cathode of the diode is dependent on the applied voltage and the tapping point along the resistor. To calculate this, manufacturers give a rating known as the intrinsic stand-off ratio of the UJT. This sophisticated sounding term simply means that the voltage thus present equals this ratio (called η or neta) multiplied by the applied voltage.

The operation of a UJT is very simple. If a voltage is applied across the base terminals, with base 2 to positive terminal, then applying a voltage to the emitter sufficient to forward bias the diode will cause the emitter-base 1 circuit to switch to a low resistance. This firing voltage will approximately equal η times the applied voltage. The device will turn off when the current through the emitter falls below the holding value. A common application is the UJT os- ▶

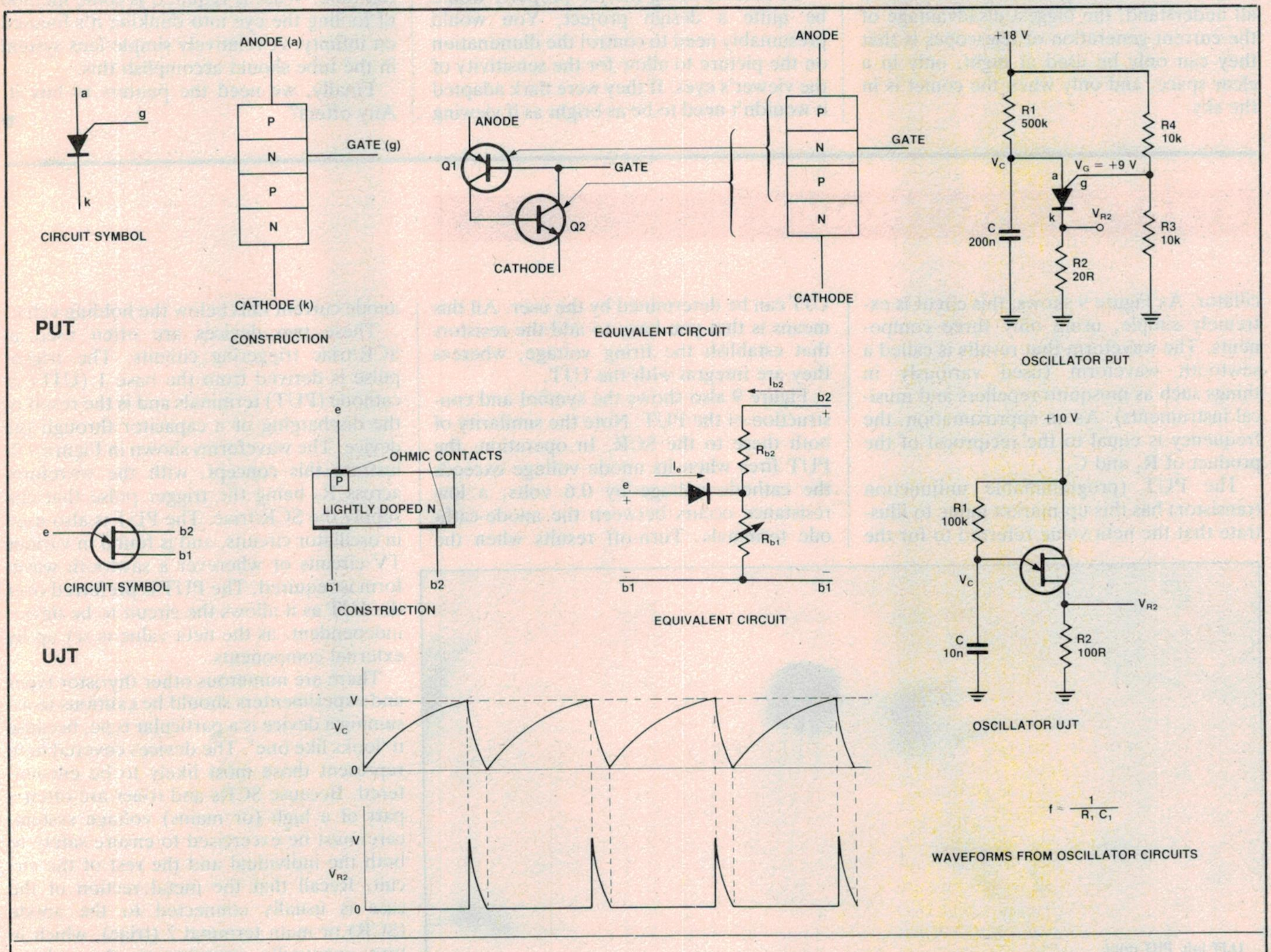


Figure 9. The PUT and UJT.

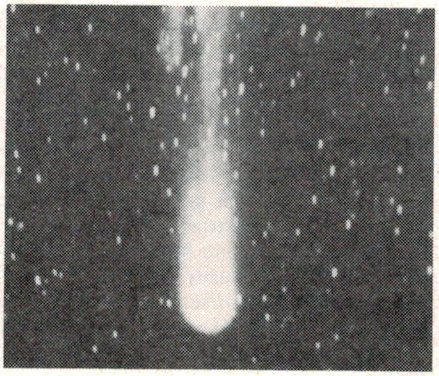
DREGS

Halley mania

Since time immemorial, the return of Halley's Comet has been an opportunity for every loony in the shire to get it together and strut his stuff. Consider the two gentlemen of Chicago, USA, who made a living all through 1910 by selling 'comet elixir', a substance designed to protect the gullible from the effects of the comet's tail. The police, ever ready to oppress free enterprise, arrested the two and caused a riot when the public realised it would be deprived of its supplies.

This time around we are all going about the return of Comet Halley with far less excitement. This is due in part to the fact that the majority of us can't even see it because of the amount of light and filth that hangs over our cities. Nevertheless some enterprising free marketeers are getting into the act and making money out of Halley's iceberg.

Here at ETI, trendsetters all, we are putting our oar in before anyone else with a decent comet hunting telescope. As you will all understand, the biggest disadvantage of the current generation of telescopes is that they can only be used at night, only in a clear space, and only when the comet is in the sky.



This is a ridiculous state of affairs. What we want is a device that is time independent, place independent, and most importantly, comet independent. The answer, of course, is a cardboard tube with a picture of the comet painted on the glass at the business end. This would allow you the pleasure of seeing the comet without ever leaving the comfort of your armchair.

Of course, doing the job properly would be quite a design project. You would presumably need to control the illumination on the picture to allow for the sensitivity of the viewer's eyes. If they were dark adapted it wouldn't need to be as bright as if viewing was done with the lights on. Perhaps a light dependent resistor on the outside could be used to determine the ambient light conditions, and interior illumination could be made proportional to this. We would also need some kind of timing function to allow for the rate at which dark adaptation occurs. The closest electronic mimic of natural bodily functions is probably capacitive discharge, so maybe a simple RC network would do. If it was a problem we could put a PROM in it and do the job properly.

The simplest form of illumination would be with a red LED, but this would lead to a highly unrealistic rendition of the comet. Why not make the picture of a material that will absorb red light and reflect it as white light? What we want is a thin film with a crystal structure that will be excited by the LED emissions, and then decay at random wavelengths.

However, even with such refinements it wouldn't be hard for the eye to detect that it was only looking at an image at the end of the tube. What is required is some method of fooling the eye into thinking it's focused on infinity. A relatively simple lens system in the tube should accomplish this.

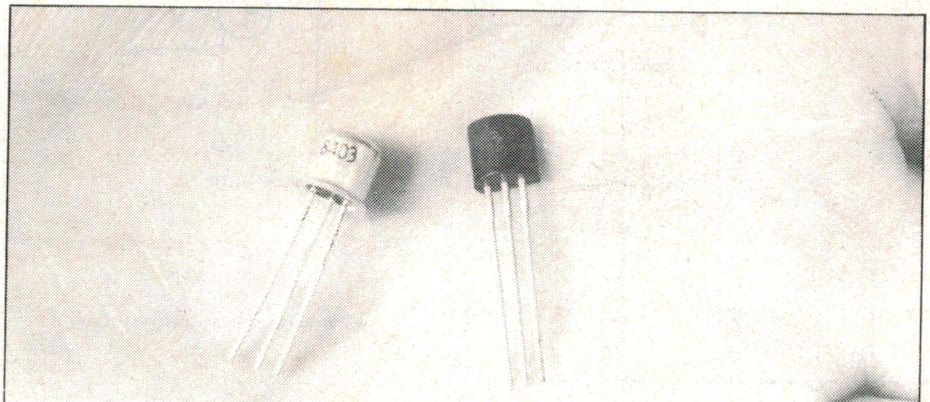
Finally, we need the punters to buy it. Any offers?

STARTING ELECTRONICS 11

cillator. As Figure 9 shows, this circut is extremely simple, using only three components. The waveform that results is called a sawtooth waveform (used variously in things such as mosquito repellers and musical instruments). As an approximation, the frequency is equal to the reciprocal of the product of R_1 and C_1.

The PUT (programmable unijunction transistor) has this up-market name to illustrate that the neta value referred to for the UJT can be determined by the user. All this means is that you have to add the resistors that establish the firing voltage, whereas they are integral with the UJT.

Figure 9 also shows the symbol and construction of the PUT. Note the similarity of both these to the SCR. In operation, the PUT fires when its anode voltage exceeds the cathode voltage by 0.6 volts; a low resistance occurs between the anode-cathode terminals. Turn-off results when the anode current falls below the holding value.



UJT left, **PUT** right.

These two devices are often used in SCR/triac triggering circuits. The trigger pulse is derived from the base 1 (UJT) or cathode (PUT) terminals and is the result of the discharging of a capacitor through the device. The waveforms shown in Figure 9 illustrate this concept, with the waveform across R_2 being the trigger pulse that can supply the SCR/triac. The PUT is also used in oscillator circuits, and is found in various TV circuits or wherever a sawtooth waveform is required. The PUT is preferred over the UJT as it allows the circuit to be device independent, as the neta value is set up by external components.

There are numerous other thyristor types and experimenters should be cautious in assuming a device is a particular type, because it 'looks like one'. The devices covered here represent those most likely to be encountered. Because SCRs and triacs are often a part of a high (or mains) voltage system, care must be excercised to ensure safety to both the individual and the rest of the circuit. Recall that the metal section of the case is usually connected to the anode (SCR) or main terminal 2 (triac), which in turn eventually connects to the voltage supply.

SCOPE

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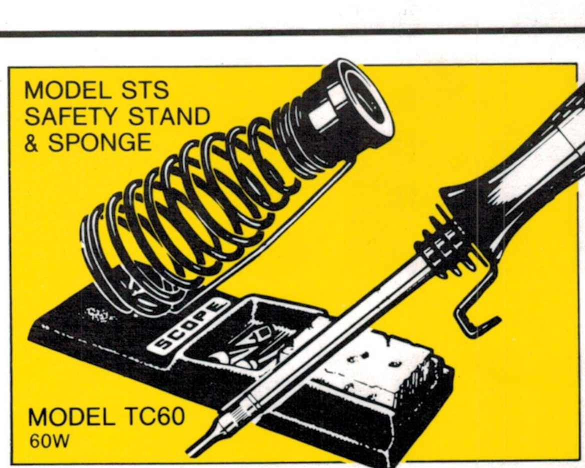

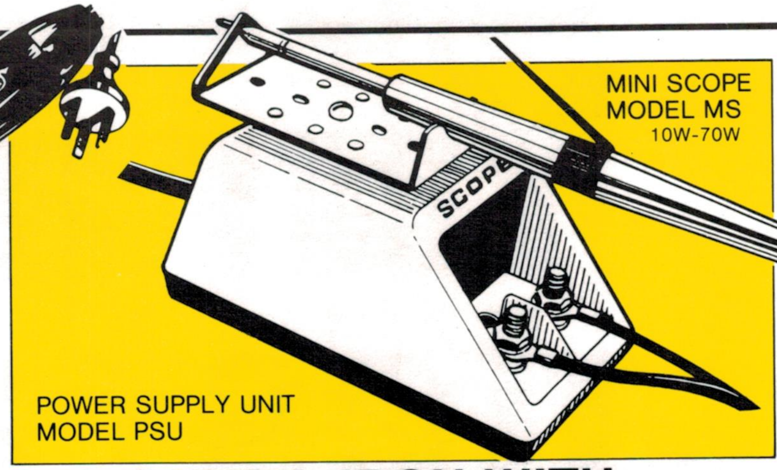

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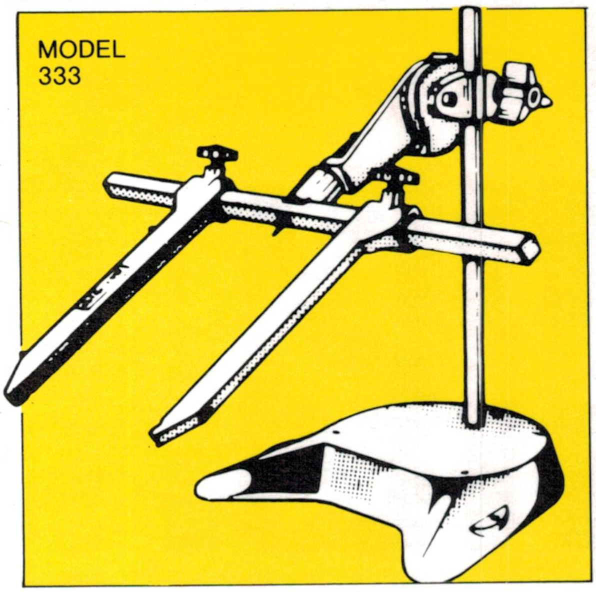

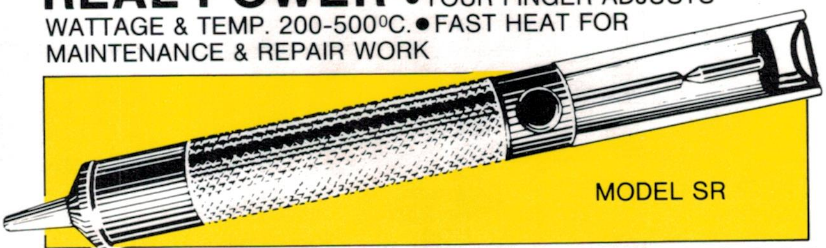

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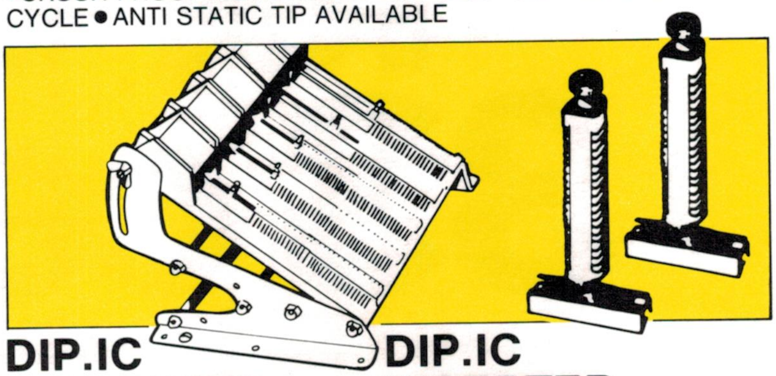

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